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Student Projects in Engineering History and Heritage

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Student Projects in Engineering History and Heritage

Abstract

University undergraduate engineering programs have technical components as well as general education and liberal arts components. Often, the various components are not integrated well, and students may not see the relationships between technology and history. On the other hand, non-engineering students very rarely take engineering courses, and thus may graduate with very limited understanding of engineering and technology and their roles in society. At Cleveland State University, a course entitled ESC 200 Engineering History and Heritage has been developed to allow students to investigate the development of technology in civil, mechanical, chemical, and electrical engineering in the context of historical case studies. As part of the course, students working in groups prepare and present an engineering history case study. The students, working in groups of 3 to 5, write technical papers and present their results on the last day of class. This allows the student groups to develop and demonstrate their communication skills as well as their mastery of the course concepts. The student projects provide other benefits. Projects that are done well can be incorporated into future offerings of the course. An example is how the development and eventual decline of the Ohio canal system influenced the growth of the state's economy, and how the canals led to the growth of the railroads that eventually overtook them.

Introduction

University undergraduate engineering programs have technical components as well as general education and liberal arts components. Often, the various components are not integrated well, and students may not see the relationships between technology and history. On the other hand, non-engineering students very rarely take engineering courses, and thus may graduate with very limited understanding of engineering and technology and their roles in society.

At Cleveland State University, a course entitled ESC 200 Engineering History and Heritage has been developed to allow students to investigate the development of technology in civil, mechanical, chemical, and electrical engineering in the context of historical case studies. The course is a requirement of the recently revised ABET accredited Bachelor of Civil Engineering (BCE) degree program, and was first offered in the spring 2011 semester. Although the course has no prerequisites and is open to any student at the University, so far the majority have been civil engineering students.

Course Description

The course was developed to meet the challenge of addressing principles that are vitally important to the professional practice of engineering, but are often difficult to incorporate in the curriculum. The objective of this course is to introduce students to the history and heritage of civil, environmental, mechanical, electrical, industrial, manufacturing, and chemical engineering. The catalog description states that the course "Examines how constraints and considerations such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability influence engineering practice. How professional and ethical responsibility affect engineering. Places the impact of engineering solutions in a global, economic, environmental, and societal context." [1]

This course has no prerequisites, and is scheduled for convenience in the second semester of the second year of the curriculum. However, some students take it during the first year instead. Offering this course early in the curriculum allows students to have a better grasp of what they will be studying over the next couple of years, and will hopefully motivate their engagement in the curriculum.

The course used two books by Professor David Billington of Princeton University as texts, *The Innovators: The Engineering Pioneers Who Made America Modern*[2] and *Power, Speed, and Form: Engineers and the Making of the Twentieth Century*[3]. The course uses a case study approach.

In some respects the course title is a misnomer. Rather than teaching engineering history per se, the course teaches engineering through history. The course is really about the engineering profession, and that probably would have been a better course title. Although the course was proposed as an offering for Cleveland State University's General Education requirements, it was not approved for Gen Ed listing by the University Curriculum Committee. As a result, few, if any, non-engineering students take the course.

A complete description of the course is provided in another paper[4]. The earlier paper also discusses similar courses at other universities, as well as the assessment of the course at Cleveland State University and some preliminary results. The course syllabus is provided as an Appendix.

Student Learning Outcomes

The requirements that civil engineering programs have to meet now, and will have to meet in the future, are contained in a number of documents. The requirements are written in terms of outcomes, which include technical knowledge as well as the ability of graduates to explain concepts and problem solving processes involving management, business, public policy, public administration, and leadership. These include the general and program specific ABET Engineering Accreditation Commission (ABET EAC) criteria[7] and the Civil Engineering Body of Knowledge (BOK)[5]. ASCE also publishes a commentary on the ABET EAC criteria[6].

The course was designed to help document that the students had achieved specific ABET Engineering Accreditation Commission[7] learning outcomes, which are:

- (f) an understanding of professional and ethical responsibility
- (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[7]

Some of these outcomes can be difficult to document in a course strongly focused on technical content. These include Outcomes (f), (h), and (i), which can be addressed through historical case studies.

Historical case studies may be used to support Outcome (j), knowledge of contemporary issues. As students review the historical development of engineering, they will realize how the past affects future practice, and can discuss contemporary issues in light of that history.

In addition, civil engineering programs have to meet program specific criteria. Civil engineering students have to be able to explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure. The historical case studies address these issues well.

Student Project Assignment

The course also included a final group project. Each group selected a historical case study topic, wrote a technical paper, and presented it on the final day of the class. This allows the student groups to develop and demonstrate their communication skills as well as their mastery of the course concepts.

Students were assigned to groups of 3 to 5 by the instructor, rather than being allowed to select their own groups. This was done to attempt to balance out the groups in terms of GPA, gender, diversity, and academic background, and to demonstrate the fact that in the future when they work on engineering teams, they will generally be assigned to teams and not select their own teammates. This also avoids the awkward situation that arises when a student is not selected by any of the groups.

The use of case studies is supported by sound pedagogical research. *From Analysis to Action*[8] refers on page 19 to textbooks lacking in practical examples as an emerging weakness. Much of this document refers specifically to breadth of understanding, which may be achieved through historical case studies. Another issue addressed (p. 19, [8]) is the need to "incorporate historical, social, and ethical issues into courses for engineering majors." This need is met directly by the ESC 200 course. The Committee on Undergraduate Science Education in *How People Learn*[9] on page 30 refers to the need to organize knowledge meaningfully, in order to aid synthesis and develop expertise.

Since ESC 200 requires students to independently research their own case studies, this provides a valuable research and writing opportunity. Engineering curricula increasingly emphasize the importance of developing problem-solving skills in engineers as well as communication skills, not just imparting scientific knowledge, so the case study approach fits well with that agenda. *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology*[10] proposes that as many undergraduate students as possible should undertake original, supervised research.

The student projects provide other benefits. Projects that are done well can be incorporated into future offerings of the course. An example is how the development and eventual decline of the

Ohio canal system influenced the growth of the state's economy, and how the canals led to the growth of the railroads that eventually overtook them. This case study, developed by a student group from the spring 2011, was included as a module in the spring 2012 course offering. This case study has also been accepted by an ASCE journal for publication[11]. Some of the projects from spring 2012 also show promise for future adoption.

The student groups were encouraged to draw extensively on the Cleveland State University Library's Special Collections for historical case study materials. As described on the special collections web site (http://library.csuohio.edu/speccoll/) "Michael Schwartz Library's Special Collections provides a research facility for our students and faculty, as well as for scholars and visitors from around the world. Our collections cover many topics within the field of Cleveland history, with special concentrations on the industrial history of Northeast Ohio, Cleveland journalism, and the city's infrastructure. We are also home to publications from the University Archives about CSU and its predecessor, Fenn College, including college bulletins, course schedules, newspapers, yearbooks, and budgets."[12] One of the class meetings is devoted to a tour of the Special Collections. Many of the materials are also online as part of the Cleveland Memory Project (http://www.clevelandmemory.org/)[13].

Project Grading

The group project represented 15 % of the course grade. The assignment stated that projects should address the following elements, at minimum:

- Professional and ethical responsibility
- The impact of engineering solutions in a global and societal context
- Contemporary issues
- Basic concepts in management, business, public policy, and leadership
- Sustainability

The group presentations took 15 to 20 minutes. Presentations are made to the entire class, and each student in the group must participate and make part of the presentation. The presentation represented half of the project grade, considering the following requirements:

- Proper use of references/attribution? Use of peer reviewed technical literature?
- Well organized?
- Graphics clear and legible?
- Language clear?
- Speaking skills?
- Kept within time limits?

The project written report was limited to 10 pages. The report represented the other half of the project grade, considering the following requirements:

- Proper use of references/attribution? Use of peer reviewed technical literature?
- Well organized?
- Graphics (figures and tables) clear and legible?

- Language clear and appropriate for technical report?
- Within length/page limits?

The requirements were provided to the students in a rubric before they started work on their projects.

Student Group Project Examples

The student groups had freedom to select their projects, as long as they fit within the overall scope of the course. For spring 2011, there were six project groups. Of those, only one group selected a project that was closely tied to the history of the region.

This group analyzed the rise and fall of the Ohio and Erie Canal. This project was able to make extensive use of the Cleveland State University Library's Special Collections[12]. As part of this project, the students visited some historical canal sites in the Cuyahoga Valley National Park. Since this project was well developed, it was added as a module to the spring 2012 course offering. The student paper was also adapted for submission as an ASCE journal paper, entitled "Rise and Fall of the Ohio and Erie Canal," and was accepted for publication. The abstract of the ASCE journal paper states:

"Transportation networks often go through life cycles as they develop, become mature, and on occasion fade away and are supplanted by newer transportation modes. The state of Ohio's first transportation network was based on canals. The life cycle of the Ohio and Erie Canal and the early economic development of Ohio were closely linked. The rise and fall of Ohio's canal system offer valuable lessons about the political and economic difficulties of embarking on vast infrastructure projects, as well as the benefits of doing so. Considerable engineering challenges had to be overcome to build the canal system. The canal system also required considerable maintenance and upkeep, and those costs played a large part in the system's eventual demise. The growth of the state economy and the rise of some of the largest cities in Ohio were direct results of the canal system. Although the canals were superseded by the railroads, in a sense they made the railroads possible. This paper reviews the engineering, economic, and political considerations that influenced the development and the eventual abandonment of the canal system."[11]

The other group projects from spring 2011 were, Nuclear Power in the U.S., Development of the Interstate System, Mayan Engineering, the Chernobyl nuclear accident, and Modern Aircraft Design.

For spring semester 2012, the group projects were, The Cleveland Auto Industry, Terminal Tower, Cleveland Baseball Stadiums, Bridges of Metropolitan Cleveland (Old Superior Viaduct and the Veterans Memorial Bridge), the Cleveland Iron and Steel Industry, and the Downstream Environmental Effects of Dams. In contrast to the previous year, these projects made better use of the Memory Project[13] resources and had a considerably stronger local focus.

The course already discussed Henry Ford and his development of the mass produced automobile[3]. Therefore, the Cleveland Auto Industry project provided an excellent complement.

One of Ford's early competitors was Alexander Winton of Cleveland. A Winton was the first car to cross the United States. The White Company of Cleveland built steam powered cars, one of which set an early speed record. White shifted later to making military trucks for World War I. Another Cleveland company was Baker, which manufactured early electric cars. The material from this group project may be integrated into future course offerings as part of the two lessons on development of the automobile.

The Terminal Tower is an important Cleveland landmark. It was the fourth-tallest building in the world when it was officially dedicated on June 28, 1930, and was the tallest building outside of New York City. This project gave the students the opportunity to discuss the history and life cycle of a land mark building, while researching the historical construction records. It was well integrated with the rail and streetcar transportation network of the early twentieth century.

Another project, on Cleveland Baseball Stadiums, reviewed the construction, use, and social impacts of three different major league stadiums built in Cleveland starting in 1891. The first two stadiums suffered minor structural collapses. The project also gave the students a chance to discuss the costs and benefits of public investment in large sports facilities.

Cleveland has a number of historic bridges crossing the Cuyahoga River downtown. One of the projects reviewed the design and construction of two important bridges, using resources from the Cleveland Memory Project[13] including an eBook *Bridges of Metropolitan Cleveland*[14]. These resources provided structural plans and construction records.

The course covered Carnegie, steel, and metallurgical engineering[2]. Another student project focused on the role of Cleveland in transporting iron ore and in manufacturing steel, as well as some key local structures that made extensive use of steel. The environmental impacts of steel manufacturing were also discussed.

One project looked at the societal and environmental costs and benefits of dams, including effects on rivers and habitat, blocking fish migration, and potential landslides. The impacts of the Three Gorges Dam in China were examined in detail. This project focused directly on student outcomes (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context and (j) a knowledge of contemporary issues.

Discussion

Two critical skills for engineering practice are the ability to work in teams, and the ability to communicate effectively through speaking and writing. These projects require the students to work in teams, and communicate their results.

The projects also require students to clearly articulate their understanding of professional and ethical responsibility, the impact of engineering solutions in a global and societal context, contemporary issues, basic concepts in management, business, public policy, and leadership, sustainability. While it may seem at first that historic case studies are not an effective way to discuss contemporary issues, there are always important parallels between the past and present that may be drawn.

For example, several states have recently leased their turnpikes to private firms, and over the past two years the state of Ohio was considering doing so as well. Since the leasing of the Ohio Canal system in the nineteenth century had proven to be so damaging to the canal systems, this historical case study provided an interesting perspective on a contemporary issue.

Conclusions

The incorporation of student projects into this course has had a number of benefits. First, it allows the students to practice communicating engineering information through presentations and written reports. Although students may get practice writing papers and making presentations in other lower division general education courses, this may not occur in an engineering context.

The use of projects with a local connection, such as the Ohio and Erie Canal and landmark buildings and bridges in Cleveland, helps the students make a connection between their local built environment and their chosen profession. This makes it much easier to grasp how engineering works affect society. It is possible to draw important parallels between the past and the present.

Finally, some of the material from the reports can be incorporated into future course offerings. Thus, some of the work of updating the course is transferred from the instructor to the student, and students can take pride in the use of their projects in subsequent semesters.

Appendix: Course Syllabus Spring 2012

ESC 200 Engineering History and Heritage

Spring 2012

Instructor: N. J. Delatte, P.E., Ph.D.

Office: Stillwell Hall 121, Phone: 687-9259, Internet: n.delatte@csuohio.edu

Textbooks: Billington, David P., *The Innovators: The Engineering Pioneers Who Made America Modern*, Wiley, 1996, Billington, David P., and Billington, David P., Jr., *Power, Speed, and Form: Engineers and the Making of the Twentieth Century*, Princeton University Press, 2006

Catalog description: ESC 200 Engineering History and Heritage (3-0-3)
History and heritage of civil, environmental, mechanical, electrical, industrial, manufacturing, and chemical engineering. Uses a case study approach with emphasis on northeast Ohio. Examines how constraints and considerations such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability influence engineering practice.

How professional and ethical responsibility affect engineering. Places the impact of engineering solutions in a global, economic, environmental, and societal context. Prerequisite: none.

Class meets twice a week for 1 hour and 50 minutes – see schedule

Class meets on Tuesdays and Thursdays, 10 – 11:50 am in SH 268

Office Hours: Mondays, Wednesdays, and Fridays 1 – 2 pm. Other times by appointment. Generally speaking, the best way to ask me a question is by email if you can't come by the office.

Lesson	Day	Date	Topics	Reference
1	Tuesday	1/17	Introduction, the ancient engineers	Handouts
	Thurs, Tues	19, 24	No class	Handouts
2	Thursday	26	The ancient engineers I, II	
3	Tuesday	31	The ancient engineers III, IV, V	Handouts
4	Thursday	2/2	Modern engineering and the transformation of America, Watt and Telford – steam engines, arch bridges	Innovators Ch 1, 2
5	Tuesday	7	Fulton's steamboat and the development of river transportation, Lowell, water power, and the American Industrial Revolution	Innovators Ch 3, 4
	Thursday	9	Ohio Canal system, Francis and the industrial power network,	Innovators Ch 5
6	Tuesday	14	Railroad engineering in the U.S., Henry, Morse, and the telegraph	Innovators Ch 6, 7
Lesson	**Day**	**Date**	**Topics**	**Reference**
	Thursday	16	No class	
7	Tuesday	21	Exam I	
8	Thursday	23	Railroads and bridges in the interior, Carnegie, steel, and metallurgical engineering,	Innovators Ch 8, 9
9	Tuesday	28	Collapse of the Ashtabula Bridge, Cleveland Inventions	Handouts
10	Thursday	3/1	Edison, electrical light, and power generation and distribution, Engineering in America – the	Innovators Ch 10, 11,

			first 100 years	Power Ch 1,
11	Tuesday	6	Edison, Westinghouse, and Electric Power, Bell and the Telephone	Power Ch 2, 3
12	Thursday	8	No class	
	Tues, Thurs	13, 15	No class – spring break	
13	Tuesday	20	No class	
14	Thursday	22	Tour – library historical collections	
15	Tuesday	27	The Wright brothers and the airplane	Power Ch 4
16	Thursday	29	Exam II	
17	Tuesday	4/3	Oil refining and Cleveland industrial heritage, Ford, Sloan, and the automobile	Power Ch 5
18	Thursday	5	Radio – from Hertz to Armstrong	Power Ch 7
19	Tuesday	10	Ammann and the George Washington Bridge, Eastwood, Tedesko, and reinforced concrete	Power Ch 8, 9
20	Thursday	12	No class	
21	Tuesday	17	Failures of Concrete Gravity and Arch Dams, Tedesko, and reinforced concrete	Power Ch 9
	Thursday	19	Streamlining: Chrysler and Douglas	Power Ch 10
22	Tuesday	24	Exam III	
23	Thursday	26	No class	
24	Tuesday	5/1	Topic TBA	
25	Thursday	3	Project final presentations	
Final	Thursday	10	*Final exam – 8:30 – 10:30 am*	*All*

Grading system:

Homework, pop quizzes, and writing assignments	15 %
Term project	15 %
Three Exams – each	15 %
Final Exam	25 %

Course Objective:

The objective of this course is to introduce students to the history and heritage of civil, environmental, mechanical, electrical, industrial, manufacturing, and chemical engineering.

Expected Outcome:

Students will be able to discuss history and heritage of civil, environmental, mechanical, electrical, industrial, manufacturing, and chemical engineering.

Engineering Program Outcomes;

ABET general outcomes:

(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) knowledge of contemporary issues

ASCE civil engineering outcomes:

Explain basic concepts in management, business, public policy, and leadership

Explain the importance of professional licensure.

Bibliography

[1] Online course catalog, Cleveland State University, www.csuohio.edu

[2] Billington, David P. (1996) *The Innovators: The Engineering Pioneers Who Made America Modern,* Wiley

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[5] American Society of Civil Engineers (ASCE) (2008), *Civil Engineering Body of Knowledge for the 21st Century*, Second Edition, ASCE, Reston, Va.

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[9] Bransford, J. D., Brown, A. L., and Cocking, R. L., (1999), *How People Learn: Brain, Mind, Experience, and School*, National Academy Press, Washington, D.C.

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[11] Kalabon, Amy E., Loescher, Eric S., Sommerville, Alice E., and Delatte, Norbert J. (2013), “Rise and Fall of the Ohio and Erie Canal,” accepted for publication by the ASCE Journal of Professional Issues in Engineering Education and Practice

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