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Using Engineering and Construction Projects to Expand Students' Knowledge of World History

Dr. Kirsten A. Davis, Boise State University

Kirsten A. Davis is an Associate Professor in the Construction Management Department within the College of Engineering at Boise State University. Dr. Davis earned a B.Arch. in Architecture and a B.S. in Civil Engineering from the University of Tennessee, an M.S. in Civil Engineering specializing in Construction Engineering and Management from the University of Colorado, Boulder, and a Ph.D. in Civil Engineering specializing in Construction Engineering and Management from Virginia Polytechnic Institute and State University. Her educational research interests are focused on improving construction management education.

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Abstract

An elective course was created to explore historic structures from various locations around the world and investigate their construction methods and the influence of political, religious, economic, social, and other factors on the construction process. Structures included in the course range from the Pyramids in Egypt and Notre Dame de Paris to the Panama Canal and Hoover Dam. The engineering and construction context aims to engage engineering and construction management students in world history in a way that is more interesting for them than a typical history course. Essays throughout the course ask them to reflect on aspects of the projects that directly relate to construction such as (1) challenges that were encountered during the construction, (2) examples of modern structures that were inspired by the projects, and (3) how construction techniques and project management have evolved over time. Students are also asked to reflect on political, economic, and social aspects of the projects, which help to engage them in the historical context and be exposed to the fact that many complexities of construction projects go beyond just construction means and methods. Based on data collected, students indicate that they are learning about more than just construction history. Many are becoming much more interested in learning about US and world events and their interest in travel abroad has also increased after learning about many of the projects. Additionally, their reflective essays indicate that they are learning many aspects of US and world history that were previously unknown to them. Details of the course will be provided for other faculty interested in creating a similar type of course.

Introduction

As part of the requirements for a bachelor's degree, engineering and construction management (CM) students take general education courses that provide a broader education than the courses within their major. These courses, particularly the required social science electives, such as history, political science, and sociology courses, are sometimes viewed as unpopular with engineering and CM students. As educators, it is possible for us to see the larger picture and recognize the value these courses provide for students, but some students view the social science course requirement as a waste of their time and they struggle to see the relevance to their future careers and lives.

A construction management elective course was created to help expand students' knowledge of both US and world history using a construction and engineering context that was more interesting for them with the hopes that it will further engage them in both local and world affairs. While this course does not currently satisfy any general education degree requirements, its aim is to engage students in how political, religious, economic, and other factors have an effect on the engineering and construction processes by providing them with a more interesting context. The course content also incorporates opportunities for reflection on construction techniques, as well as different leadership and management styles encountered on some of the historical construction projects included.

Literature Review

Integrating historical perspectives into engineering and STEM coursework is valuable for improving students' broad understanding of complex topics by reaching beyond purely technical content and giving them insights into human factors that influence those topics [1]. Evidence suggests that integrating arts and humanities topics into disciplinary STEM courses is associated with improved "higher order thinking, creative problem solving, content mastery of complex concepts, enhanced communication and teamwork skills, and an increased engagement of learning" [2]. It helps students connect material from the classroom to real-world challenges and their broader societal implications, encouraging them to consider multiple perspectives when tackling those challenges [3], [4]. This integration produces more well-rounded engineers and construction managers, as well as more responsible citizens of the world [5] in a more palatable way for those that prefer technical topics to the humanities.

Constructivism, a learning theory that emphasizes constructing new knowledge by building on the learner's existing knowledge [6], provides a theoretical foundation for this course on historical construction projects. Students enter the course with at least a basic understanding of engineering and construction topics and have previously taken high-school level history. The integration of history, construction, and engineering encourages students to build a deeper understanding of each, particularly if they are excited to learn about at least one of the subjects. Etkina and Mestre [7] discuss how knowledge construction is most effective when facilitated by instructional strategies that emphasize context, collaboration, and critical inquiry. They advocate for active engagement in problem-solving and reflection to enable deeper conceptual understanding, which aligns with the aim of this course to integrate historical and technical knowledge.

The relationship between learning about history topics and civic engagement is also well-documented. For example, Ford et al. [8] and Loewen [9] demonstrate that teaching history through interactive and reflective methods not only enhances students' academic skills but also fosters a deeper connection to their roles as informed citizens - they are likely to connect their learning about past events with present-day societal challenges and complexities.

Course Design

The "How Did They Build That?" course is offered as a 3-credit elective course in the Construction Management dept at Boise State University. Currently, the prerequisites are a 100-level construction materials and methods course and upper-division status. Most students who take the course are construction management majors, but over the lifetime of the course, there have also been civil, mechanical, and electrical engineering, visual arts, art history, and urban planning majors. The class meets once per week for 3 hours and is a mixture of mini-lectures, videos, hands-on activities, and in-depth discussions. A list of readings used in the course is included as an appendix to this paper.

There are three main goals for the course: (1) adding to students' knowledge of methods and equipment commonly used to construct buildings and heavy civil projects, (2) becoming familiar with historical building techniques and how they have evolved over time, and (3) developing an

appreciation for how politics, religion, economics, and other local, regional, and/or world factors, can affect construction projects.

A list of modules included in the course is provided in Table 1 below, followed by more information about each module. The modules are taught roughly in chronological order to allow students to see the evolution of construction materials, equipment, and techniques more easily. At the completion of each week of the course, students write an essay that asks them to reflect on aspects of the projects that directly relate to construction such as challenges that were encountered during the construction and how construction techniques and project management have evolved over time. Students are also asked to reflect on political, economic, and social aspects of the projects, which help to engage them in the historical context and expose them to the fact that many complexities of construction projects go beyond just construction means and methods. Some examples of essay prompts are also included.

Table 1: Course Modules

	Module
1	Pyramids
2	Colosseum in Rome
3	Obelisks, Washington Monument
4	Cathedrals, Notre Dame Cathedral in Paris
5	Domes
6	Transatlantic Cable
7	Brooklyn Bridge
8	Panama Canal
9	Hoover Dam

Module 1: Pyramids

The course begins with a two-week module about the Pyramids in Egypt. In the first week, a brief introduction to the evolution of Egyptian pyramids is presented, followed by a focus primarily on the Great Pyramid (also known as the pyramid of Khufu or pyramid of Cheops) for the remainder of the module. We brainstorm possible ways that the Great Pyramid might have been built, saving judgement on their likelihood and practicality until the conclusion of the module. Some examples that usually come up include: aliens, ramps of various design, time travelers, slaves, rollers, giant cranes, and levers. We try to grasp the scale of the project by comparing the size of the pyramid's footprint to our campus and its height to tall buildings in our city. For homework between the two classes on this topic, students read a journal article on one possible way that stones were moved to build the pyramid, as well as a short book that presents a different theory.

In the second week of the module, we dive deeper into the scale of the project, looking at how many stones must be moved and how quickly to accomplish the roughly 23-year project, as well as where they came from. We look at simple 'machines' (the lever, wheel, pulley, wedge, and screw) and learn which ones were known to the ancient Egyptians, as well as tools that they were known have, such as sleds. Then it is time to refine our brainstormed list and come up with what might really have worked to build the Great Pyramid. We add in recent information acquired from archeological work that adds to our knowledge, and refine some more, ending with a small

list of ways the Great Pyramid might actually have been built. We finish the module by discussing political, economic, and social issues that could have been encountered on this project.

A reflective essay prompt used for this module asks students to imagine that they have traveled back in time and will oversee the construction of this pyramid.

> What method(s) would you employ? What do you think would be your biggest challenge(s)? If you could bring one modern piece of construction equipment back with you, what would it be and how would it help? What would its limitations be? If you could talk to someone who really did build the pyramid and could ask them one question, what would it be? Why? If you could visit the completed pyramid today to search for clues on its construction that would help with your imagined plan, what would you look for? What would you want to investigate? Why? How might managing a project like this help (or hurt) your future career?

Module 2: Colosseum in Rome

Prior to the classroom portion of our second module, students watch documentaries about Roman engineering and the Colosseum. In the classroom, we look at the breadth of the Roman Empire's engineering feats with its roads, bridges, aqueducts, arenas, baths, domes, and tunnels. Then we study the Colosseum in Rome and what we know about its purpose, materials, size, schedule, and more. A hands-on activity with blocks explores arches and vaulting, used extensively in the Colosseum. We discuss tools and equipment used by the Romans, such as groma (a survey instrument used to make perpendicular lines) and chorobates (leveling devices), and look at different ways to move large stones with wheels, winch and pulley, and block and tackle. Early versions of scaffolding and centering for arch construction are also examined. We watch a documentary that seems to dispel some theories around a portion of the Colosseum's construction. We again finish the module by discussing political, economic, and social issues that would have been encountered on this project.

Module 3: Obelisks, Washington Monument

In preparation for module 3, students read a short book about Egyptian obelisks (they may choose between two books). In class, we watch a documentary and discuss possible ways that obelisks were created, moved, and erected by the Egyptians before looking at the details for how obelisks were relocated from Egypt to other parts of the world. Several relocations are quite well documented, including one moved at the Vatican in 1586, one removed to Paris in 1831-1836, one to London in 1877-1878, and one to New York in 1879-1881. We also look at the construction of the Washington Monument (which is not a true obelisk but was designed to resemble them) between 1848-1888. This module in particular allows us to look at the progression of devices for lifting very large and heavy objects. Prior to the course, most students have never even heard of obelisks, but by the end of the module there are long class discussions about whether obelisks should remain in their current locations or be returned to Egypt, similar to other nations that are now requesting that their national treasures be returned.

Module 4: Cathedrals, Notre Dame Cathedral in Paris

Homework prior to module 4 includes a short reading excerpt and several documentaries about cathedrals. In class, we discuss the purpose of cathedrals and the general process for cathedral

building, and then focus on Notre Dame cathedral in Paris. Alongside learning about the gradual construction of Notre Dame with all of its starts and stops between 1163-1330, we look at lifting devices, scaffolding, centering for arches, and flying buttresses. With an appreciation for all that went into its construction, we then discuss the fire that occurred in April 2019 and the stabilization and reconstruction that has been taking place since then. Discussions about the decisions made for reconstruction take center-stage with all of the political, social, economic, religious, and construction challenges that accompanied those decisions.

Module 5: Domes

Module 5 looks at the construction of domes spanning nearly two millennia. Students watch several documentaries on domes prior to this module. We begin in the classroom with the Pantheon (117-123), an unreinforced concrete structure. Next is Hagia Sophia (completed in 537), a brick and mortar dome, followed by the Florence Duomo (1420-1436), which is also made of brick, but is actually two domes – inner and outer ones – and St Peter's Basilica (1585-1590 plus 1743-1744), which continued the brick double dome technique with refinements. Next is St Paul's Cathedral (1668-1711), which is an inside masonry dome, an outside lead-covered timber dome, and a brick cone in between which supports the masonry lantern. Finally, we end the module by looking at the US Capitol (1855-1866) which is similar to St Paul's but is constructed with cast iron pieces, and we also discuss the recent (2014-2016) restoration project of this dome.

Module 6: Transatlantic Cable

Students read a short book about the Transatlantic Cable in preparation for Module 6 and we watch a documentary in class to help visualize the ships and equipment used at the time. Students are often not familiar with this project and assume that it has nothing to do with our modern communication systems, but by the end of this module, they are much more aware of the day-to-day usage of modern undersea cables, as well as their vulnerabilities – from earthquakes to intentional damage, both of which have occurred in the very recent past. This module encourages discussions on quality control, financing large projects, and the politics involved in multinational construction projects. Additionally, this is the first module where we have a known project manager to study in detail and most students are in awe at the resiliency and perseverance of Cyrus Field.

Module 7: Brooklyn Bridge

The Brooklyn Bridge is a three-week module that begins with a documentary on bridges in general before we tackle the Brooklyn Bridge in detail. The students read a rather long book about this bridge, but the reading is spread over three weeks, making it a manageable workload. Our first week in the classroom is primarily focused on the politics and financing involved in getting the bridge started. We dive into the political parties of the late 1800s and some infamous characters that were major figures in the project, such as William "Boss" Tweed. This is not a favorite part of the project for students, but it's important for them to see how much of a project timeline might happen before construction starts. The second week of this module is focused on working conditions, safety, quality control, and the construction of the towers. The third week completes the module (and the bridge), focusing on the suspension cables and road deck construction, as well as safety and quality control on the project. In weeks two and three, we are also able to discuss the project management methods of Washington and Emily Roebling. In

addition to discussions, the students also build small bridges out of provided materials, such as newspaper and masking tape, during two of the class meetings and we load them to failure.

Some reflective essay prompts used for this module include:

> Choose and briefly describe a challenge that has been encountered in building this bridge. What surprised you about the challenge? What did you expect? Do you think challenges like this are encountered in projects built today? Why or why not? If you were to encounter a similar challenge on a project today, how might you handle it?
> What aspects of the project management of the bridge by Washington and/or Emily Roebling were most interesting to you? Why? What lessons can you learn from them that you can apply to your future career?

Module 8: Panama Canal

The Panama Canal is a two-week module. To reduce the reading load, particularly about politics and financing, an overview of the initial stages of this project is provided in the classroom, after which students are asked to read several chapters about the US portion of the construction, beginning in 1904. Two documentaries are also included in this module to supplement the reading. Discussion topics for this module include the working, living, and safety conditions, project management styles of the three men in charge over the US period, challenges from geology and geography, and politics. We also bring this project to modern day by looking at the canal expansion completed in 2016 and the water issues that currently reduce the number of ships that can pass through the lock system.

Some reflective essay prompts used for this module include:

> What do you think were the biggest challenges encountered by immigrant workers when compared with American workers building the canal? Consider housing, pay, and other aspects in your writing. What challenges / discrepancies / discrimination like this do you think still exist on today's construction projects? How might you prevent these types of challenges from occurring on projects you manage? What lessons can you learn from the project managers (any or all of them) on the Panama Canal that you can apply to your future career?

Module 9: Hoover Dam

Our final module of the course spends two weeks looking at Hoover Dam. Similar to the previous module, a brief overview of the political and financial sides of the project is presented in class and subsequently students read most of a book about the dam, focused on the construction portion of the project beginning in 1931. During the first week, we focus on learning about the Great Depression, which forms the context for this project, as well as the construction of Boulder City and the diversion tunnels. Discussions center on working, living, and safety conditions, the project management style of Frank Crowe, challenges from geology and geography, and politics. There are also connections between this project and the location of our university, so some local construction history is also discussed. In the second week of this module, we focus on building cofferdams, excavation, and concrete construction, as well as intake towers and tunnels required for power generation. Discussions include changes brought about by labor unions because of projects like this, the evolution of the Federal Government due to the Great Depression, and changes in jobsite safety from then until now. We also bring this

project to modern day by looking at the water issues that continue to surround this project due to droughts and over-allocation of the Colorado River, as well as the renegotiation of water distribution that is ongoing.

Findings

Questions from the instructor have been included in student evaluations for six course offerings. Quantitatively, students indicate that the course has increased their knowledge of US history, world history, and construction history. A scale of 1=strongly disagree to 5=strongly agree was used and 39 students responded with the following results:

- *This course has increased my knowledge of US history*. Overall Mean = 4.69
- *This course has increased my knowledge of world history*. Overall Mean = 4.72
- *This course has increased my knowledge of construction history*. Overall Mean = 4.82

Unfortunately, the individual student response scores are not available in the evaluation data for all semesters, so it is not possible to accurately report high, low, and other statistics.

Students were also asked to respond to two open-ended questions. The questions, along with a sampling of responses are included below.

Question 1: *How has this course changed your interest in learning about different types of history?*

- "this class gave me more interest in world history and that of humanity"
- "I did not know much about many of the projects we discussed before this class. Additionally, I was able to learn about the politics and economy of different cultures throughout time and across the world as well as get more background on what things were like in the US during some of these projects."
- "I never really engaged with history classes throughout my childhood. In high school I never really found it interesting, but this course has definitely changed my interest. Learning about these cultures around the world and more about the US through the lens of a construction manager was really cool and thought that I got great value out of this class"
- "I see history differently now. Construction is part of everything whether it's war or politics, every historical event most likely has some sort of construction attached to it."
- "Not only has it relit my interest in history itself, but also my reading. I feel as though I got out of habit of reading and while it was required to read for the course, it wasn't anything that I didn't want to not do. I really enjoy the political and social factors that surround the projects, especially as we get closer to the current date of the projects."
- "I have a much better understanding for what politics can be in construction."
- "it showed me there is value in learning things from the past and knowing how things have previously been accomplished."

Question 2: *How has this course changed your interest in world events? Study abroad? Other things?*

- "Brought my interest to world events where before I had no interest."
- "There's things I want to go and see now all over while paying more attention to the construction of it rather then the tourist aspect!"

- “I would love to be able to see each structure we discussed in person and would have definitely been interested in study abroad following this class.”
- “After learning about ancient civilizations and the construction feats they built I have gained the strongest desire to go out and see them for myself. The study abroad program that would go along with this course would be amazing.”
- “I never realized the scale that some construction projects take a role in current world events. Whether it be the Panama Canal restricting passages or the lowering water level of Lake Mead, the projects that we do will also affect our communities even if it's not on a global scale. This summer I will be going to at least three of the projects we have discussed in this class and I'm very excited because of the level of knowledge I now have on their construction.”
- “Makes me want to stay updated on current affairs going on throughout the world”
- “It has opened my eyes to things that are happening throughout the world today and why different countries react the way they do.”
- “It made me want to learn more and pay more attention about world events. Not just about things that happen in the United States.”

When reviewing the student responses, including those not listed above, it is clear that many of them are learning about a great deal more than just a few historical construction projects. Most of the student responses indicated interest in traveling to visit the projects and that the course sparked their interest in learning about other historic projects. Many indicated that they were more interested in following world events than prior to the course and they have a better appreciation for how those events can impact even seemingly local construction projects. Even though many of them have never traveled outside the US, they are now more worldly in their knowledge.

Implications for Construction

A university course such as this has the possibility of influencing construction practice in a number of ways. This course helps to produce more well-rounded students who are more aware of how the world impacts their construction projects, as well as how their projects impact the world around them, which should produce better future construction managers. They will be able to see beyond their project, recognize how political, economic, environmental, and societal impacts may have an effect on it, and be more adept at managing those impacts. For example, in March 2021, the container ship EverGiven was grounded in the Suez Canal for six days, dramatically impacting global shipping by causing delayed deliveries and increased shipping costs. By having an increased awareness of global events such as this, a construction manager can recognize the potential impact to their schedule and/or budget and make modifications to lessen those impacts.

Many of the essay assignments throughout the course prompt students to reflect on the leadership and project management demonstrated in the projects. Students are asked to analyze behaviors and attributes they admire and aspire to emulate, as well as ones they aim to avoid. Traits such as resiliency and perseverance are commonly mentioned as positive qualities students wish to adopt. They are also asked to think about challenges that occurred and how they might handle a similar challenge on a future project of theirs. For example, several of the projects examined in

the course had some level of discrimination due to race or immigrant status. These are challenging topics to tackle, but by asking students to actively think about real situations that occurred in the past, they are more likely to be able to effectively tackle a similar situation on a future jobsite.

Learning about historical construction projects can also inspire students to approach future challenges on their projects with creativity and innovation. By studying how past engineers and constructors overcame technical, logistical, and societal hurdles, students gain valuable insights into problem-solving and adaptability. These examples can serve as a foundation for developing unique solutions to modern-day construction challenges they may encounter.

Future Directions

Future improvements for this course include the expansion of course content to include additional projects, as well as adding an optional study abroad component to the course. Additional projects would allow the instructor to rotate the content from one offering to the next reducing potential instructor boredom after many semesters. Two optional study abroad trips have been preliminarily planned, but neither has been implemented at this time. There is definitely student interest, but it will require careful control of costs to allow students from our university the ability to participate.

There is also an opportunity for research on the long-term impacts of this course on students' careers and worldviews. This would be challenging research requiring a qualitative approach because of small class sizes (typically 15-20 students per offering). It would also require a longitudinal study following students after graduation and it might be difficult to isolate the impact of this course from other more personal aspects that may also influence them. Even though a study such as this would not be generalizable to the larger construction management population because of the methods required, it could still present some interesting findings.

Conclusion

In the construction management elective course "How Did They Build That?", students not only learn about historic construction projects, but also learn about US history, world history, and construction history through the context of those projects. Many of the projects are still regularly seen in the news (for example Notre Dame's recent reconstruction, the Panama Canal's current water woes, and Hoover Dam's ongoing drought). Because students now have connections to these historic projects, they are more likely to be aware of global events that have an impact on these and other projects. This greater awareness will position them to be better construction managers, able to recognize potential impacts to their projects and successfully navigate those impacts. Students are also learning valuable leadership and project management skills by analyzing others' work, with an emphasis on admirable and effective behaviors and attributes. Additionally, they are gaining knowledge about creative ways to solve problems, enabling them to be leaders in their future construction management careers.

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Appendix

Course Readings (in the order they are assigned in the course):

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