Benefits of Utilizing 'Existing', Real-World, Civil Engineering Projects in a Capstone Course and the Civil Engineering Capstone Project Depot

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This paper presents the benefits of utilizing an 'existing', large scale, civil engineering project in a capstone design course and introduces the Civil Engineering Capstone Project Depot as a source for these projects. Utilizing 'existing' projects that have been designed and built or are waiting to be built provides the students with a significant real-world experience and allows the course instructor to control the project start date, duration, scope, and work flow. The 'existing' project format also allows for the comparison of the students' designs with the actual project design.

Course instructors that obtain projects from the Civil Engineering Capstone Project Depot can eliminate the stress of finding acceptable capstone projects and can reduce their workload prior to and during the semester. Projects available in the Civil Engineering Capstone Project Depot contain all the design calculation and reports as well as the live working MicroStation drawings, all of which have been generalized to eliminate student discovery of the actual project name and location.

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Introduction

The capstone design course offers engineering students a culminating design experience on an applied engineering project. With the requirements of Accreditation Board for Engineering and Technology (ABET) Criteria 3[1] and requests from industry, capstone courses have become common in engineering departments across the United States.[2] Numerous papers have been published on capstone design courses justifying the need for a real-world experience as well as providing details on course operation, assessment methods, and project sourcing. Howe's 2005 study shows a decided shift toward external project sourcing to meet the real-world experience, but details concerning the actual project sources were not a component of the survey.[3] Nilsson's 2012 survey indicated that 78 percent of responding programs with capstone courses indicated using 'current' (under construction) real-world projects and 83 percent indicating using 'future' (could be designed and constructed) real-world projects.[4] It should be noted that this 'select all that apply' question allowed for a sum greater than 100 percent. This same survey also found that industry partners provided 80 percent of project ideas.[4] A number of papers support the concept of utilizing real-world 'current' and 'future' projects for their capstone project and obtaining the projects from industry.[5,6,7] A literature review of papers on capstone courses did not find any engineering programs using 'existing' projects. For this paper 'existing' projects are defined as projects that have been designed and built or are waiting to be built. This paper discusses many advantages and a few disadvantages of utilizing an 'existing' project in your next capstone course and also introduces the Civil Engineering Capstone Project Depot for obtaining such projects.

Realizing the Need for Using 'Existing' Projects

Marshall University for the past three years has utilized civil engineering projects from local government entities that have been designed and built or are waiting to be built. This was a solution to the poor experiences with capstone projects that involved real time design projects over two consecutive course cycles. The projects utilized had issues with project launch time, project delays, minimal number of sub-disciplines, uneven design team workload, and erratic work flow, just to mention a few. These issues were very frustrating for the students and instructor.

After reviewing the issues that occurred on recent projects it was determined that an alternate project source was needed: a real-world project that could be controlled by the course instructor. The solution was found in obtaining the design files and drawings from an 'existing', real-world, large scale, civil engineering project that was designed and built or waiting to be built.

Benefits of Using an 'Existing' Project

Many benefits exist for using an 'existing' project in a capstone course. Some of the major benefits are presented below with examples.

It is Real!

It is a real-world project! First and foremost an 'existing' project provides a real-world experience, because it is a real-world project. The project was actually designed and the capstone students must work through the same issues as those that the practicing design professional encountered. Students like the fact that the project is a real-world project that was actually designed. Students also get a kick out of the fact that the course instructor did not design or create the project. The students realize there is no preconceived design solution and they control what solution develops.

Civil Sub-Discipline Interaction

As required by ABET Criteria 3, student design teams are able to experience team interaction due to the large project format. Within civil engineering team interaction most frequently occurs at the sub-discipline level. Civil engineering sub-disciplines (geotechnical, structural, transportation, hydraulics, hydrology, and environmental, etc.) interact, exchange information, and jointly design many aspects of a project. In a capstone course, design team interactions are created by selecting project design components that generate design conflicts. An example of significant team interaction occurred when the structural, transportation, and geotechnical design teams worked together to site a new bridge. Each team had issues important to their design that conflicted with the other two design teams. The groups successfully worked through all the issues to arrive at a final bridge location agreeable to all teams.

Student Experience

Students can self-select which sub-discipline design team within civil engineering they would like to practice. With an 'existing' project the potential design components for each sub-discipline can be presented to the students and the students can gauge their interest in each sub-discipline. Students invest more time and effort in their work if they are working in an area that interests them personally. If they see themselves working as a geotechnical engineer, they will thrive if working on the geotechnical team; conversely, if they are required to work outside their area of interest they will not put forth the effort needed to produce a quality design or benefit from the capstone design experience.

Students look forward to comparing their design to the actual design of the practicing design professional. Because the actual design drawings, calculations and reports are available for review at the end of the semester, the students have the opportunity to compare their work. The students' confidence soars when they realize that they produced nearly the same design as the original practicing professional engineer.

Instructor Experience

An instructor benefits from the 'existing' project format because the course instructor can select the project months ahead of the beginning of the semester allowing time for review of the project and preparation of all the needed project documents. This eliminates the stress of finding a project and reduces the instructor workload prior to and during the course.

Data Availability and Dissemination

Data availability and control is a central benefit of using an 'existing' project. Because the project design has been completed by the practicing design professional, the project data needed such as; boring logs, structural loads, run-off data, etc. are available, when it is requested by the individual design teams. This eliminates the real-world data collection delays that occur on real time design projects. For example, when a subsurface exploration takes place during a real time project the geotechnical engineering aspects of the project are on hold for two to four weeks, time not available during a one semester course. With an 'existing' project the subsurface data is in the instructor's hands at the beginning of the course, so when a student team requests this data it can be provided in a timely manner.

Another data availability advantage occurs if a design sub-discipline is not represented by a student design team. If a hydrology student team does not exist and a site/civil design team makes a request for run-off data for culvert design the course instructor can reference the actual project data, act as the hydrology team, and provide the requested data.

Data availability also assists with teams designing in parallel. In order to complete the required designs within a one semester course many of the design teams must work in parallel, not in series as would happen in the real world. Since the project data is known, the course instructor can provide the information as each team requests data. The design teams still interact, learn what information each other needs, and how the information evolves and changes hands. It is impractical for the geotechnical team to wait weeks for the structural bridge team to provide foundation design loads. To eliminate this delay the instructor can provide the loads from the

project documents allowing the geotechnical team to proceed with their design. This produces an even work flow throughout the semester for all teams.

Project Control

The ability to control the work flow and scope-of-work for each team is an enormous benefit of using an 'existing' project. The instructor is in control of the project and therefore the course, not the project controlling the course. Both the students and the instructor become frustrated and stressed if the project is not ready to start on time or when uncontrollable and unanticipated circumstances disrupt the project, putting completion of the project in jeopardy. With an 'existing' project the instructor controls the work flow.

With a large scale project there are typically numerous components that can be designed. Therefore, the scope-of-work for each team can be set based on the number of teams, the number of students in each team, the difficulty of the selected design elements, and the need to generate team interactions. Team assignments can be adjusted so that all teams have an equivalent workload. If a particular design component becomes easier than anticipated to design then an additional component can be added to the design team's scope-of-work; conversely, if a team is struggling with the completion of their design, the instructor could provide additional information to move the design along.

An 'existing' project also eliminates the delays that can be experienced on typically real time projects like owners putting the project on hold, permitting delays, the design leader not being available.

Drawbacks of Using an 'Existing' Project

A major drawback in using an 'existing' project is the inability to conduct site visits. Conducting a pre-design site visit or viewing site photographs is not recommended because these activities would provide too much design guidance to the design teams. This typically is a vital step in the design process, especially in the site/civil or geotechnical sub-disciplines. Unfortunately, a work-a-round for this issue has not been developed.

A minor drawback is that sub-discipline design teams are at times given the final design solutions of another design teams. Teams could pass this information to other design teams that are actually developing this information, therefore providing additional design guidance. Fortunately, over the last three years no confidential data sharing has been observed.

The Civil Engineering Capstone Project Depot

The **C**ivil **E**ngineering **C**apstone **P**roject **D**epot (CECPD) was established as a project source for civil engineering capstone course instructors. CECPD is a Google Drive™ site containing the past 'existing' projects that have been utilized in Marshall University's senior civil engineering capstone course over the last three years. The project folders contain all available design calculations and reports in PDF format as well as all of the live working MicroStation files. Each project folder also includes a summary on which design components worked well and which did not. The files are downloadable and modifiable as needed.

All the MicroStation files and many of the typical design documents utilized by the students have been generalized. Generalization eliminates all indications of the real project name/location, original design firm, and project owner. Generalization of the files prevents the students from researching the actual project location, reviewing the existing design, and producing the same design.

The CECPD currently contains three different projects and will continue to grow every year as new projects are added by Marshall University or other contributors. The goals of the CECPD are to promote the utilization of 'existing', large scale, civil engineering projects in capstone courses, provide a project source that a capstone course instructor can use to obtain a new project each capstone course cycle, and to encourage interaction among capstone course instructors.

Conclusion

Based on the benefits gained by utilizing 'existing', large scale, civil engineering projects, Marshall University has had three successful capstone cycles and plans to continue using this format. In an effort to promote this project format at other universities a project depot has been created to provide interested capstone course instructors with projects.

This paper presented some the benefits of utilizing an 'existing', large scale, civil engineering project in a capstone design course and introduced the Civil Engineering Capstone Project Depot as a source for projects. Utilizing 'existing' projects provides the students with a significant real-world experience with the ability to compare their designs with the actual project design. Course instructors that acquire projects from the CECPD can eliminate the stress of finding an acceptable project, reduce their workload before and during the semester, and control the project start date, duration, scope, and work flow in their course.

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