Simulated Construction Management Through Web-based Observation of an On-Campus Construction Project

Nicholas V. Kissoff
University of Toledo

Abstract

A unique experience was afforded The University of Toledo Construction Engineering Technology (CET) program through the cooperation of a local construction manager. The construction of a new multi-story student residence hall on campus was to be managed by a firm that had also developed its own web-based project management/workflow software system. The CET program was offered access to this system which allowed for remote observation of the day-to-day construction administration of the two-year project. Student access to the project was tied to the department's required senior project capstone class. A select group of students from that class were then able to connect with a project that they saw everyday on campus.

The student team was responsible for an established set of project administration tasks that were to be performed on a periodic basis throughout the semester. Team members were required to take on multiple roles throughout the project, acting as construction managers, sub-contractors, owners representatives and design consultants in order to address the situations that arose randomly based on the actual construction progress. Communication of construction progress was also fostered through required class presentations.

Students gained the ability to make real-time decisions regarding the project and gain exposure to valuable lessons in the process of construction management. Additionally, the students gained exposure to the use of a web-based document and workflow process that is becoming the norm in the construction industry for control of complex projects. This paper chronicles and analyzes the development of the first in a proposed succession of similar semester experiences for CET students in the senior capstone class.

Introduction

Many, if not most engineering and engineering technology programs offer some form of capstone project course which is designed to encompass and exhibit the skills and knowledge obtained by graduating seniors during the four years in their program. The project is considered to be a culmination of the students' education and a springboard for the type of work that they may encounter in their chosen careers. Programs within The University of Toledo's Engineering Technology Department are no different. In order to gain an economy of class size and maintain consistent guidelines for the projects and presentations between disciplines, students in each of

the four programs (Construction, Mechanical, Electrical and Computer Science) are pooled into the same capstone project course which is supervised by one instructor. The students are then split into teams according to their discipline. Each team of three or four students then seeks out a faculty member from their specific program to be their advisor. The faculty advisor aids the students in choosing a project and gives technical assistance as needed throughout the semester. Student teams prepare a project proposal, give periodic project updates and produce a final set of project deliverables in order to satisfy their class responsibilities. Projects can vary widely dependent upon each team's discipline, their interests and their advisor's guidance.

The mission of The University of Toledo CET program is to prepare students for career positions in all phases of construction. Nearly one half of the program's graduates begin their professional careers with contractors or construction management firms. However, past history has shown that the student teams tend to choose projects that center mostly on design. This is not entirely surprising when considering the logistic, financial and legalistic difficulties that a team would face in a one semester class if the group were to attempt some type of construction project to perform. Some construction oriented tasks, such as final cost estimates or proposed construction schedules, have been incorporated into past team efforts. However, the large majority of the tasks within past projects have been purely design in nature.

The incongruity between project choice and program mission had not been lost on the CET faculty or its industrial advisory committee. Discussions and investigations were held in an attempt to develop a more appropriate and comprehensive capstone choice for those students whose calling was not design but construction contracting and management. The CET program was particularly concerned with providing more hands-on, real-world construction coordination issues within the project course, while at the same time attempting to keep the framework of the departmental capstone course intact in its current form. Upon further investigation of the experiences of other construction programs, several new and unique methods were evaluated.

Recent initiatives have been underway to establish an interactive web-based learning tool for construction education. The Interactive Construction Management Learning System (ICMLS) has been under development for several years at Arizona State and Western Michigan University with the aid of a National Science Foundation grant.[1,2] This program allows construction students to make real time decisions and see the results of their construction management decisions via 3-D modeling. The development of this system is still in its infancy and was seen by the CET program administrators to be a future solution for individual coursework in construction. Other programs have also attempted to utilize 4-D modeling and other web-based simulations or gaming techniques to provide a real-world construction experience with some success.[3,4] Again, these techniques seem to be best suited for individual coursework rather than a capstone experience. The construction program at Pittsburg State University (Kansas) offers a real world construction project for their students.[5] Faculty and students have teamed together to establish a pseudo-construction company which procures small local projects for the students to construct, subcontract and manage. This format however requires intensive work on all parties parts. In many cases it necessitates more than one semester of time and requires the involvement of both lower and upper-division students from the program for the duration of the project. A similar program exists with community-based programs at North Dakota State University which has provided a service-learning experience with successful

results.[6] The department that houses the Pennsylvania State University/Harrisburg construction program provides a one year duration capstone course that features industry representatives, field trips and intensified team development of construction situations for their seniors in order to tie together their construction curriculum.[7]

These successful examples notwithstanding, it appeared that no single solution was available to satisfy the goal of the CET program to have a real world construction capstone project. Combinations of any of the aforementioned methods or the development of other capstone methods would require a large time commitment to develop into a viable solution. This was a commitment that no one individual within the CET program had the ability to make.

An Offer from Industry

In the midst of this discussion, during the winter of 2003, the CET program along with both the UT Civil Engineering and Computer Science Engineering departments, were extended an invitation from individuals associated with a local construction management firm. Owners and associates of the Bostleman Corporation of Toledo, Ohio had developed a web-based workflow and construction management software system. The stand alone company they founded (ProjectVillage, LLC) offered to meet to discuss how partnering with the University could mutually benefit both parties with regards to their new ProjectVillage™ concept. The ProjectVillage™ system operates in some of the same manners as many Project Specific Web Sites (PSWS) except that it is built around their Enterprise Community® structure. This structure allows each participant to control its own project information and choose which portions to share with which organizations. ProjectVillage™ offers the ability to create custom online workflow paths to route construction documentation to the proper project participants. It also includes an online plan room where bid and construction documentation is stored for use in the management process[8].

Whether there were uses available for construction education or opportunities for research to further develop the system, the ProjectVillage organization had no firm objectives in their offer. However, one facet of the initial meeting between the parties was very intriguing to the CET program. The construction of the new $45 million residence hall on The University of Toledo campus was to be managed by the Bostleman Corporation. All construction administration for the project, which was to begin in the Summer of 2003, was to be handled using the ProjectVillage™ system. This opened up a promising avenue which could allow students from the CET program to not only watch the progress of a major project on campus, but also to experience firsthand the processes that develop within the administration of such a project. The proposal to allow access to the ProjectVillage™ system for a limited number of students from the CET program during the construction of the residence hall was presented to the ProjectVillage organization and was accepted.

The Project, Course Development and Objectives

The use of PSWS's have been successful in other capstone courses as a tool to facilitate the coordination of design documents[9]. The ProjectVillage™ system had previously been used in an educational format in tutorial fashion at Virginia Tech[10]. Students were led through a step

by step simulated design change over a period of several days. While this format was something that was beneficial to the construction class in which it was utilized, the UT CET program wanted to attempt something a bit less structured and more realistic. The most logical use of this unique offering was to allow a student team from within the senior capstone projects course to access the ProjectVillage™ system and to follow the construction of the residence hall to satisfy their class requirements. However, it was desirable to have the student team do more than just observe the project on the web and visit the construction site. Preferably the students would also have some hands on experience with open-ended problems that would foster learning similar to the other teams in the capstone class that had chosen design projects. The target was to offer this option to one team in the Fall 2003 projects class. The time prior to the fall semester afforded the faculty advisor the ability to access the ProjectVillage™ system and observe the construction as it commenced in late spring. This allowed an evaluation of the project and a determination of what course of action to take regarding student responsibilities.

The residence hall construction project itself was a multiple bid package project which contained multiple firms with differing responsibilities. Separate consultants took roles as design engineers and project architects which oversaw sub-consultants in discipline specific roles in the structural, mechanical, electrical and civil design roles. Nine separate subcontractors were awarded bids under the Bostleman Corporation which acted as the lead contractor and project manager. The construction consisted of two main, five story residence hall structures interconnected with two ancillary service structures. The project was to be located in a student parking lot, in a newer portion of the campus, loosely filling in open space between two other nearby residence halls and two administration buildings.

Study of the project as it began over the summer offered a chance for the faculty advisor to get a feel for the ProjectVillage™ system and it's capabilities. During the first bid package that focused on site preparation, it was apparent that the project would have its fair share of correspondence regarding requests for information (RFI's), field instructions (FI's) and extra work authorizations (EWA's). Large, multiple bid package projects that are state sponsored frequently tend to have a fair amount of coordination administration during the project and this one seemed to be no exception. Additionally, through a central homepage location, students would have access to project meeting minutes, work progression photos, and subcontractor payment requests (see Figure 1). Through the ProjectVillage™ system PlanRoom portal, access to the latest bid and construction documents was also available for research and verification of any clarification or coordination issue that arose on the project. One negative aspect regarding the project was the lack of an updated project schedule within the system. This was a function of the project manager's desire not to post the information rather than a lack of functionality of the ProjectVillage™ system.

With a feel for the system and project in hand, the faculty advisor and the capstone course instructor developed specific goals and tasks for the student team chosen to attempt this management project. In addition to the standard capstone project objectives of working in a team environment, synthesizing accumulated knowledge into an open-ended design project and fostering communication skills within their area of expertise, the student team was provided the following additional objectives:

- The ability to work in a realistic hands-on construction management experience.
- The exposure to have to react to open ended situations beyond the student team control.
- The opportunity to have to "jump in feet first" into a project which had already begun and would require the team to "get up to speed".
- The ability to gain experience in presenting construction information and updates in a proficient and coherent manner.
- The ability to gain familiarization with project administration duties.
- The ability to gain familiarization with leading edge project workflow software.

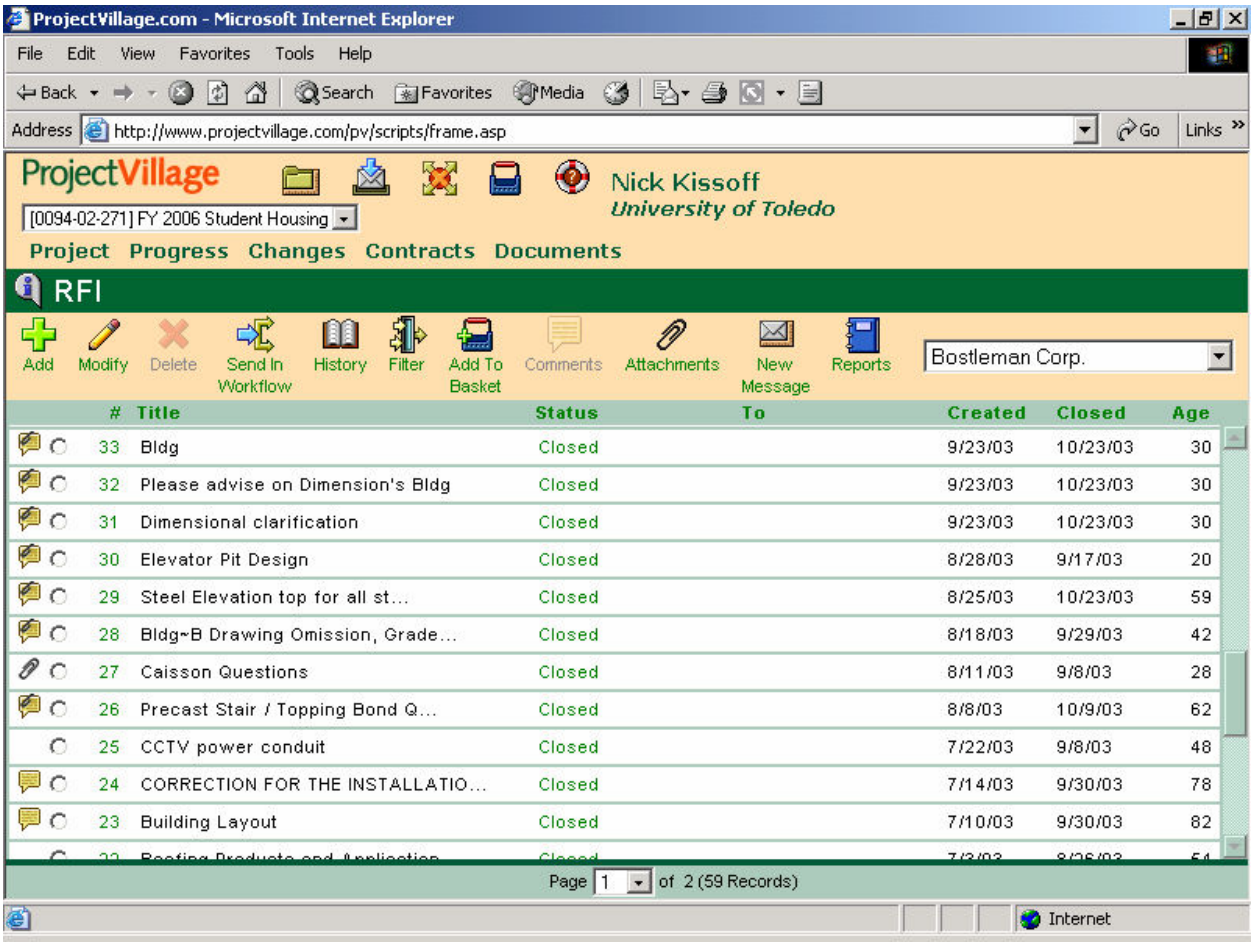

Figure 1: ProjectVillage™ RFI Screen

The normal provisions of the capstone class requires student teams to produce and present an initial project proposal, periodic progress presentations and a final presentation in which the teams' final designs are showcased. For the student management team, these presentations were required to take the form of construction updates and information sessions where the students could hone their skills at describing construction progress to those less versed in its terminology. Additionally, without the design aspect of the management project, the student team would be required to produce a different type of deliverable. Over the course of

each week, beginning after the initial proposal, the team would be required to perform the following tasks:

- Address an RFI, EWA or FI on a weekly basis.
- Address an action item from the construction meeting minutes on a weekly basis.
- Verify a subcontractor pay request on a monthly basis (for a total of 3 requests).

It was apparent at the outset of the semester that the tasks required of the team were predicated upon actual items occurring during any week of the construction of the residence hall. Some leeway would be given to the team to allow for times when no action items arose. Action items were to be addressed with a narrative and full back up documentation attached to the response. The responses were to be kept in a team binder for periodic review by the faculty advisor. Each response was required to be independently checked and verified by another team member for quality assurance. While no deadlines were implicitly given for each response, it was generally accepted that the team was to be finished with its response prior to the actual response being posted on the ProjectVillage™ system. This did not prove to be a troublesome problem since there was normally a sufficient response time allowed by the project workflow.

Access to the ProjectVillage™ system was arranged so that the student team would have rights only to view the information in the system. System permissions were restricted which prohibited the posting of comments or messages to one another. This allowed the observers to be invisible to the remainder of the construction project team and keep any inadvertent directives from being sent through the system. Additionally, the University's project manager agreed to allow the team experience to occur on the condition that neither he nor his employees be required to spend any time with the student team. This unfortunate condition, while understandable, left the student team unable to visit weekly project construction meetings or to gain direct access to the work site. In order to prevent wandering or daring student access into the site, a clause was written into the appendix for the capstone class directed at the CET student management team. Students were threatened with failure of the class were they to be found inside the construction area. Fortunately, the construction site had 360° of site visibility from outside the construction fences and this condition did not severely hamper the first semester trial of the project.

Normally, students choose teams on their own due to familiarity with other students or through a commonality of class and work schedules. In order to ascertain the effectiveness of the management project, a team of students was pre-selected prior to the start of the semester. Students were selected on the basis of their past academic performance and their maturity and work habits that they had exhibited in past classes. While all were traditional students, the three chosen team members each had outside work experience. One was employed as a technician for a county engineer's office, one as a survey crew chief for a consultant and the third as an inspection technician in a construction services department for a consultant.

Project Progression and Results

During the first four weeks of the semester the student team prepared for the proposal presentation and familiarized themselves with the project after receiving training on the ProjectVillage™ system. After the proposal presentation, the student team began monitoring the

website for action items to address. During the initial weeks of this process, the student team readily sought advice from the faculty advisor on which of the items to choose to address. Counsel was required on which action items would be acceptable, which were too trivial and which were not beyond the abilities of the team. Some items did require extensive design work with information that was not readily available to the team. Approximately one-third of the items posted on the project site were left unattended due to the abovementioned conditions. When both parties became comfortable with the procedure, less structure was required in the selection process and the team operated mostly on their own in selecting items to address.

The weekly number of addressable items varied greatly and in some weeks there were no items available upon which to operate. However, after this occurred early on, extra items during busy weeks were addressed and held in reserve in order to meet the weekly quota. In the end, the weekly quota was abandoned as the team addressed everything within their capabilities that was posted. Additionally, during slow weeks, the team would check the construction schedule and discuss situations that led to the delays and how the work could be accelerated.

By the end of the semester, the team addressed six RFI's and three FI's. Items within this area ranged from providing additional information for grade beam, foundation and steel locations, to pricing for cold weather masonry work due to a schedule delay, to the design and pricing of an extension of a waterline for concrete truck cleanout. All of the items were addressed and checked internally by the team. Additionally, all of the items were completed prior to the posting of actual resolutions on the system which allowed for a back-check to occur against the actual response for accuracy. Four weekly meeting minutes were reviewed and interpreted as to their importance to the project. Three subcontractor pay requests were reviewed, one for subsurface foundations and two for concrete foundation work.

Near the completion of the project, the student team was asked to complete individual formal questionnaires regarding their experiences during the project. Each student felt that the experience was worthwhile and that the educational objectives of the project were satisfied. Students reported each working between five and ten hours per week on their responsibilities (searching the website, visiting the site and addressing action items) which appears to be historically commensurate with the other team projects in the class. Several hindrances did arise during the course of the project which the students felt could be addressed for future attempts of this type of project.

The lack of a paper set of plan documents was perceived to be a problem. The original consideration was to use documents only from the ProjectVillage™ system since these would be the latest and most correct versions. However, not having a set of paper drawings left the team with a more difficult search for pertinent drawings on the system. While the ProjectVillage™ system contained the most up to date construction drawings (including the second and third bid packages which were issued during the semester) it was cumbersome to find the proper drawings to view due the file numbering convention, the viewing software required and the size of the plan files. Due to the prohibitive cost of plotting a full set of plans, a used set was finally obtained near the end of the semester from a local supplier. The team decided not to utilize the plan set by that point, although they did admit it would have made locating details much easier during the project and would have provided a quicker overall view of the construction.

Site access was also a minor problem. While the construction site was off limits to the team, the views provided from outside the fences early in the semester allowed for easy observation. As the semester progressed, views were obstructed due to the soil stockpiles that were amassed against the fence along both long axes of the site. Additionally, as the structures began to be rise, the sight lines decreased even more. The team felt that the ease of providing solutions to many action items was directly related to the amount of site access that could be obtained. They also felt that the work was capable of being performed without any site observation, but that more access would greatly enhance the experience.

The team felt that the project was a good test of the education that they had obtained throughout their academic career. Addressing action items drew on a combination of their class work, their part-time work experience and good old fashioned common sense and diligent searching of the documents. They also felt that the size of the team allowed them to be flexible enough in their assignments, yet allowed for everyone to be able to experience the project to the maximum extent possible.

Conclusions

While it was difficult to precisely determine the success of the experience, one could see the team take hold of the project as the semester progressed. The team would meet with the faculty advisor in order to discuss the project in a manner befitting of someone who had taken ownership of the job. The students truly began to understand the processes involved in a project of this magnitude, and gained an appreciation for more of the project than just the items that they had chosen to address. They played their roles perfectly and enjoyed doing so. The project was a unique and welcomed departure from the normal design-based projects and would be a fitting location from which to develop future and more large scale forays into the construction management arena. These future improvements notwithstanding, the results obtained from this small-scale experience were superb considering the relatively minimal faculty preparation time that was required to set up the project.

There were and are some downsides to such an experience. Students in other disciplines within the capstone course failed to see this assignment as anything more than a glorified field trip even tough the team operated upon the project in a simulated manner. It is also difficult to see how this project could currently be extended in its present format to any more than one team of three or four students in any one semester. The possible lack of construction activity on the project would result in a deficiency of unique assignments for multiple teams and thus would hamper the team ownership atmosphere of the project. Additionally, even though it may be possible to extend this type of experience off the boundaries of the campus, the advantages of the proximity of the construction would be difficult to duplicate away from campus. Both of these concerns would hamper the ability for this type of project to replace a majority of the design-only projects for CET capstone teams as was originally hoped. Nonetheless, the project remains a good tool for construction motivated students and should be taken advantage of whenever given the opportunity to do so.

Current plans call for another offering of this experience to a team in the Spring 2004 semester. After that time, the construction should progress to the point as to obscure details that

would be required in order to address certain action items. Attempts will be made to improve the site access for the student teams for any future trials.

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NICHOLAS V. KISSOFF

Dr. Kissoff received his B.S. ('80) and M.S. ('83) in Civil Engineering and Ph.D. in Engineering Science majoring in Transportation ('88) all from The University of Toledo. His industrial experience includes eleven years at SSOE, Inc. in Toledo, Ohio as a transportation design engineer and project manager. He is currently an assistant professor and the Director of the Construction Engineering Technology Program at The University of Toledo.