A Case Study of a Design-Build Competition in a Construction Program

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This article summarizes a case study involving construction science and interior design students working collectively during a design-build competition. Described in the paper is the value of collaborative teaching strategies and methods in a construction program. Also discussed are the positive aspects and implications of using real-world projects, involving the constraints of owners, constructors, budget, and time in the classroom. Graduate level students and outside instructors as scholastic resources and group mentors, respectively, and the roles they play are also discussed. Positive aspects of using building information modeling (BIM) software in collaborative study for design and construction and its use as a tool through which to cooperate are included in the case study. Limitations of project size versus student body size and the problems that may arise are touched upon. The long-term effects on Associated Schools of Construction (ASC) programs utilizing a new project delivery method in conjunction with program coursework are also described.

Keywords: Case Study, Collaborative Teaching, Design-Build, Building Information Modeling, Competition

Introduction

Each semester brings with it a new set of opportunities and challenges faced by both the instructor and student. The instructor is faced with the opportunity of reaching, through the dissemination of knowledge, another young mind and the challenge of finding a way in which to accomplish that goal in a limited amount of time. Students face the opportunity of gaining new knowledge that might aid them for the rest of their lives and the challenge of understanding the information, having the motivation to learn, and simply staying interested in the content.

Given the opportunities and challenges seen by both sides of the equation in academia, how is this equation brought into balance? In a construction program, is the dissemination of knowledge as simple as handing out notes, a book, and following up with a lecture: a "one-way street" approach? Should courses within a construction program be taught as a "two-way street," a more collaborative approach? If a two-way street is the answer, how can BIM be used to facilitate this approach? The answer to these questions lies in the industries that the construction programs support. The scene in the construction industry is ever-evolving, with many players sharing responsibilities and blurring the lines between the roles that they traditionally played. Gone are the days of the singular master builder. However, the future holds the promise of "master collaborators." Still being perceived as having problems, most based on what might be called operator error, the design-build approach to modern construction offers the closest solution to achieving a "master collaborator" method in which to practice the art of constructing.

This design-build approach as presently defined includes the cooperation of the owner, architect (designer), engineer, constructor, and tradesmen. Nowhere in the design-build equation should a single entity or individual be considered more important than another; a one-way street in this method leads to a dead end. Design-build is based on cooperation, communication, and the concurrent dissemination of knowledge between all parties, typically in real-time. According to the Design-Build Institute of America (2005), design-build project delivery will come to a break-even point with the more traditional, design-bid-build approach by 2010 and surpass it soon after. The days of "throwing a construction set over the cubicle wall" to the next profession seem to be coming to a close. The cooperation that is fundamental to the design-build approach will be a strong catalyst for its growth and the use of BIM software programs. In BIM, the entire computer-aided design (CAD) universe is connected and one object is holistically linked with all others in a three-dimensional construct. The software is designed with the hypothesis in mind that all users are working on and toward the same goal, product, or construct. Independent research has shown that design-build, if practiced as prescribed, will bring a project in budget, in less time, with few complications, and at a higher quality than does the traditional design/low bid approach (Beard, Loulakis, and Wundram, 2001). Due to this latter acknowledgement, the design-build approach within the construction industry has grown in popularity and contractual method. In a construction program the students are our future players within the industry. If they are to keep pace, they should be taught in a manner that closely mirrors that future.

The paradigm of teaching this collaborative approach in a construction program, as described below, should include "real-world" projects (with industry professionals as owners and constructors, along with true budgets and finite schedules) from the programming stage to the construction stage, multiple groups of students, a faculty member assigned as mentor to each group, and graduate level students assigned to each undergraduate group as scholastic guides and problem-solvers. As with any premise derived from a design-build approach, two-way communication between all groups and members is key. Given all of the players in this endeavor, one must recognize the difference between cooperation and collaboration and act accordingly. To cooperate is to work together for mutual benefit, while collaboration focuses on working together to achieve shared goals (Kvan, 2000). On a fundamental basis, it was not until each group had deciphered what its mutual benefit would be through the achieving of shared goals that it really came together to embrace the group dynamic.

The Opportunity

The project that was presented to the class, in the case study at hand, consisted of a national television show and its local talent (a working developer with a local market share) looking for a group of students to be a part of a competition. The competition project was to design and perform a cost analysis on a multifamily housing neighborhood. The class was made up of eighteen (18) students that formed three groups made up of construction science and interior design students. Each group had the potential of winning a cash prize that would be divided equally among group members. All groups would be assigned a mentoring instructor and a graduate student to help with the cost analysis.

Further, creating a new delivery system whereby an owner or developer works with an ASC university program for fundamental programming/schematic design phases and then takes that work to a professional architectural/ engineering or design/build firm was another opportunity upon which the course capitalized. This paradigm for a "living laboratory" allows an ASC university program to work directly with industry to create "bridging documents," those documents that non-licensed designers might create prior to handing them over to licensed professionals. All the while, students gain a great deal of knowledge and hands-on experience. Internally, the opportunity to showcase the university, the department, and an ASC university program and its developing research was a further bonus. The class would be infused with on-going research in BIM, design-build project management, and construction fabrication methods.

The Challenge

This competition was attacked as a design-build project by the class from the beginning. The deliverables for the competition, given the time constraints of a given semester, were for the completed design only. Although the client expected only a completed design proposal, it was expected that the design proposal include all site work, parking, landscaping, "connections to surrounding environment," and completed buildings.

The students were well aware that the winning design would be built and that the winning team members, along with others in the course, would have the opportunity to be a part of the construction process. Group members were also aware, due to the nature of being a part of a television show, that their design and cost work would be documented and highly scrutinized. The challenge in this course, as it is in industry, became how to create the best design and have the lowest price point per square foot. This challenge was fundamental in the teaching process. The fact that the students had to work both in collaboration with one another and within the constraints of a real world project caused the students to raise their own levels of work ethic and achieve more than they believed they were capable. Further, each student was faced with applying the knowledge that they had acquired during their past years in the program. To the surprise of the students, and due to the pressure associated with time and budget, knowledge they thought they had forgotten or they believed was simply "filler," came to them in their time of need and began to prove to them the value of their education.

Another challenge in the process was how best to facilitate the engagement of the students and the overall structure of the learning process. This particular class was already made up of an interdisciplinary group of undergraduate students, so the decision was made to carry that example a step further and include students from different levels of degree (i.e., graduate level students.) These graduate level students, specifically students seeking a master's degree, were tasked to aid the undergraduate students with the budget and economies of scale associated with individual building components to entire structures. Further, instructors from outside the course, on their own time, were tasked to guide each group with all facets of the programming, design, and the best fabrication method the group might use during the construction phase.

The Journey

The beginning of the competition found the students working in a traditional mode. Although students were working in groups, each student had a unique strategy in dealing with the project and program. Due to the nature of the interdisciplinary group of students made up of construction science and interior design, each set had its own strengths and weaknesses when it came to working within a group, deciphering the program, and creating a design from scratch.

Working with instructor/mentors and graduate students, each group found its way to completely different designs, along with different fabrication and delivery methods.
Between the three groups competing during the semester, the following design and construction scenarios were formed:

- An entry based on traditional, stick-built construction coupled with a panelized wall system that would be cost estimated in conjunction with a general contractor.
- An entry based on modular design and construction methods using wood stud structure, coupled with national cost estimating software that would be amended with local pricing.
- An entry based on modern design and an on-site material fabrication facility using steel stud and lightweight prefabricated roof structures of corrugated steel having a semicircular cross section. The cost estimation would be performed by using on-line, (localized) construction bidding websites to "shop" the project.

Once each group had direction, the work began in earnest. Using BIM software, specifically Revit v.9, each group began to "build" its design from the site up. The interdisciplinary approach to this project was fostered by the use of BIM software, in that the construction science students could inform the design students, in real-time, why certain components of the building must be used at specific places or points within the structure. Likewise, the interior design students were able to use the BIM software to their advantage and quickly work out design issues in three-dimensions, while showing the construction science students the logic behind a particular space plan or the placement of certain design features. Working with BIM, each student or group of students was able to see ideas develop in three dimensions right in front of them, which greatly enhanced the level of knowledge disseminated and the speed in which it was absorbed. However, all students were plainly directed to use BIM as a tool and not as an end unto itself. The students were to question and come up with answers to those questions, using BIM to help design and ultimately prove those answers, not to overwhelm the nurturing of design thinking (Cheng, 2006).

Each member of a team was included in all facets of their designs, some wearing multiple hats during the semester. Construction science students developed working skills as designers and the interior design students marveled at how many different parts and pieces truly make up any given building. Although the acts of cooperation and collaboration won out in the end, the journey was fraught with those students fighting internally to lead and those students who were complacent to bear the absolute minimum of responsibility. Surprisingly, the latter group of students began to rise to the occasion as they became aware of being included, not commanded to be a part of the overall group project. The level of work and attitudes that follow were in flux at times during the semester, simply due to the nature of pressure associated with constraints and deadlines. The competition, although not designed in the beginning as such, became a semester project with the three groups of students acting semi-autonomously and keeping their own design ideas and price points close to the vest. A competitive but civil spirit prevailed throughout the semester and aided each group and each member to work diligently until the end.

The Discovery

The holistic nature of this project, combined with its competitive underpinnings, allowed the students and instructors to learn a great deal about what it is to learn, apply knowledge, work as a group toward a common goal, and experience what your profession might ask of you on a common basis. The students involved in the project were commonly overheard citing work they had done before, sharing scholastic knowledge and personal experience, and working out problems faced as individuals, in a group format.
The students were motivated amazingly well by the level of work that was asked of them, along with the nature of the project. Theoretical projects or projects based solely from a textbook were rated much lower by the students as compared to this project and others that had components embedded with "real-world" or real-time scenarios and conditions. Further, it was obvious to the instructors and students alike that the BIM software was a strong collaboration tool. The BIM software was said to "keep us [the students] honest." Not only did the BIM software allow for collaboration on ideas and objects, it further forced the students to work together due to the nature of the program integrating all parts of an object. If one part of the object is edited, added to or subtracted from, by one student, it is readily apparent to all others working on the same object. The latter concept fosters a strong sense of collaboration, pre-design, and preparation prior to actually using the software. The students began to understand what impact the concept of design-build, along with BIM software, might have on the industry, namely, a reduction in errors and omissions leading to an overall, net gain in cost and labor efficiency.

Along with the students, the instructors began to see the power of cooperatively teaching a multi-degreed, interdisciplinary approach to course work, and the paradigm of the "living laboratory." It became apparent throughout the project that a greater level of product was being produced by the students, both individually and as a group, due to the nature of cooperation, shared ideas and goals, and the learning environment in which they were placed. The idea was proposed that this project, in its design development phase, would be carried on through other upper-level courses, such as construction estimating and construction administration and site organization in the hopes of creating a paradigm from which a capstone course could be designed.

Conclusion

The course ended with a bang. During the semester, healthy competition arose between the three groups of students, and if asked, each group would quickly tell the other why they were going to win. The strength of a particular design or the low price point garnered by a particular estimating process were both points of verbal contention and cajoling and at times, could lead to heated debates. Any instructor would relish the sight of students discussing a project and the roles they play in it, heated or not.

As the final days of preparation approached and presentations of student work were brought to a close, anticipation was palpable and emotions were high. The morning of the final presentations were met with the television cameraman setting up for "shooting" and the talent, along with colleagues, preparing to question the students about the semester's events. The method of presentation would follow a professional course where each group of students would present, without the other remaining groups of students in the room.

It was decided that each group would stand or fall on its own merits, both in what was shown in each presentation and in what was said. No one group would benefit or capitalize on the verbal misstep or some informational insight that another group produced. The television show talent would be considered the principal-in-charge (PIC) of a development group and each group of students would consider itself as a design-build team within the development group.
This latter condition set the tone for how the student groups would present and to what type of audience they were presenting.

Figure 1: Group 2 perspective, showing traditional architecture and materials.

All groups were allowed to present what they thought would be important to show or speak about their particular design, as long as they produced a site plan, a floor plan(s), an entry elevation, a materials board, and a break down of construction cost. In the end, all three groups, using Revit v.9 as their tool, produced the latter minimum requirements, along with numerous elevations (Figure 1 above), three-dimensional perspectives (Figures 2 and 3), and various animated walkthroughs. Each group also produced hardcopy handouts documenting the presentation material and included a detailed cost analysis, along with additional drawings and images.

Figure 2: Group 3 site perspective, showing modern architecture, materials, and Quonset-style roof.

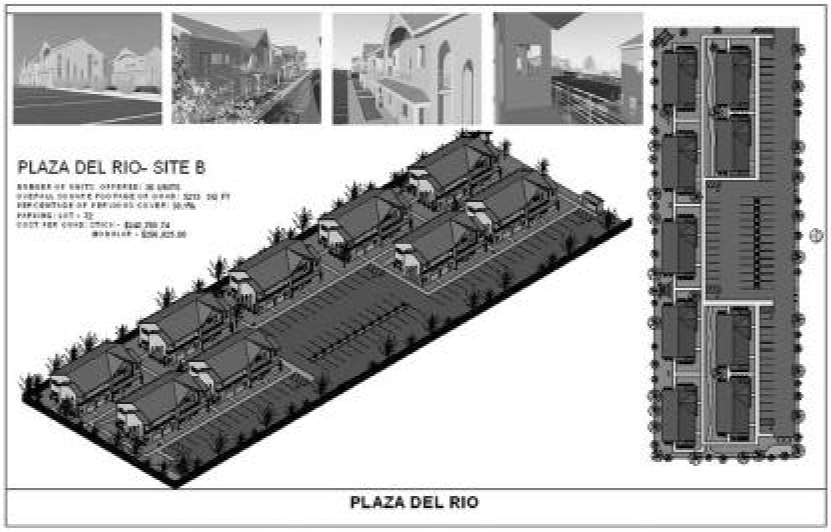

Figure 3: Group 3 presentation board, with title block, showing site plan and perspective, along with images of buildings placed on site.

As the presentations began, each group filed into the designated conference room, set up their work as seamlessly as possible and began to present (Figure 4). It was readily apparent to all including the talent, that the students had done their homework and even went so far as to work on a little showmanship. All groups presented in a professional manner, fielding questions as they were given them and worked through their designs in a logical manner, concluding within their allotted thirty minute time constraint. Upon finishing, the last group to present stepped out and the wait began for all. The talent and his colleagues took roughly an hour to discuss and talk with each instructor assigned to a group about specifics dealing with design and the validity of price points.

Figure 4: Student presenting in front of cameras and client.

The student groups were eventually brought back in as a whole and the talent discussed why a particular choice was made and a particular design was chosen. Once the decision was voiced, one group was shocked and elated, one was deflated, and one was simply angry.

After the proverbial smoke had cleared, those who won were congratulated by those who did not. Those who had won were presented a check giving each student five hundred dollars as a prize. The prize was not considered a scholarship due to the nature of scholarships being tied to the administering university body and having to be used for certain, scholastic purchases. Although extremely happy to receive the cash award, no comment was made afterward about the award being the main motivation behind the hard work that each student put into the semester. As a motivating tool, awards help to recognize outstanding work, but the understanding that a student's work will be highly scrutinized by faculty and peers alike presented a more valid tool.

Although the body of this course was made up of eighteen students, this particular course typically accommodates twenty-four students. Twenty-four to thirty students would seem ideal for a project of this nature; given that it was a competition and same number groups are appropriate for maintaining an even playing field. The given class of eighteen broken down into three groups was, at times, stretched by the amount of work to be done; however, too many individuals per group fosters inefficiency in workload and allows some students to "hide" from individual responsibilities.

Upon the conclusion of the course, students were verbally questioned about what it was they had learned (if anything) and how this course ranked compared to past coursework and why? Some of the results to this questioning, considered anecdotal, are shown as follows:

- 100% of students ranked this course as one of the most interesting, simply due to the nature of the project and the media exposure.
- 90% of students said that they had learned something fundamentally new, some bit of information that was not shown or explained to them prior. (This "new" information fell across two particular lines: some design concept that construction science students were not aware of or a particular construction or cost estimating method that an interior design student was not aware of.) (Roughly 10% believed that they knew it all… confidence is a wonderful thing.)
- 80% of students stated that had they known at the beginning of the semester what they knew at the end, they would have stayed in the course to the end. (The remaining 20% stated, in general, that this style of learning, etc. led to a lot of hours outside of regular class time that had been earmarked for other activities.)
- 100% of students were excited by the prospect of working on "real world" projects and believed that by doing so, this gave them a relevant talking point to discuss with potential employers.
- Students had mixed responses to the assigning of graduate students to their groups, but most comments related directly to individual work ethic issues and not to the concept.
- Students had an overall positive attitude towards the instructor/mentor assigned to each group and found that this one-on-one type of approach made the instructor more approachable both during the project and outside the project. This latter statement was seen as an extremely positive comment, especially when considering freshman level courses and the retention of the students within. However, a certain level of respect and hierarchy should be present where a professional level of familiarity can be fostered, but not overstepped.

- Working with BIM software was seen as a positive aspect of the project, both by design and construction students. The particular software package had never been used by either set of students and was seen as user-friendly and far surpassing traditional two-dimensional CAD packages. Comments were made pertaining to past group projects that students had participated in where two-dimensional CAD packages had been used as the design or drawing tool and how individual students could isolate themselves within the project, wasting time and effort on drawings or objects that did not benefit the group or overall project. Further, the students acknowledged that to do the latter within BIM was difficult and had caused them, on some level, to work more cohesively.

It is the conclusion of the authors that the integration across disciplines and degree level, coupled with projects directly related to or including industry is not only a valid teaching tool, but completely necessary to an ASC university program and its individual direction. The direct incorporation of industry, projects and standards, into the classroom makes the instructors and student body more adaptable to the ever-changing landscape that is construction science and construction management. The creation of a new delivery system by any and all ASC university programs gives each program the opportunity to develop research opportunities and give added value to their students and the industries they serve, alike. The "living laboratory" approach to ASC university program coursework creates a more dynamic and applicable paradigm for how students should and will learn their way through the construction science and management industry.

References

Beard, J., Loulakis, M., and Wundram, E. (2001). *Design-Build: Planning Through Development,* McGraw-Hill.

Cheng, R. (2006, July 6). *Questioning the Role of BIM in Architectural Education.* [WWW document]. URL http://www.aecbytes.com/viewpoint/2006/issue_26.html

Design-Build Institute of America (2005). *Non-Residential Design and Construction in the United States,* Washington, DC.

Kvan, T. (2000). Collaborative design: what is it? *Automation in Construction,* 9(4), 400-415.