Integrating Industry Sponsored Projects into Residential Capstone Course Curriculum

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This paper describes a pedagogical approach to teaching residential construction capstone courses involving the collaboration between industry and students in the planning of housing developments. The purpose of the course curriculum is to provide students with a theoretical and experiential based understanding of key components of the residential development and construction process including market analysis, site analysis, site planning, residential design, entitlements, marketing strategies, management planning, estimating, scheduling, and customer service planning. Theoretical course content is administered through lectures, assignments, and examinations and is graded according to individual performance. Experiential content is incorporated through semester projects and is evaluated by group performance and individual peer reviews. Industry sponsors contribute basic project details, including site locations and housing designs, and assist student teams through guest lectures, site visits, and direct correspondence. Accrediting agencies and industry advisory councils have emphasized the importance of integrating practical components in construction education and this course pedagogy does so through facilitating industry and student collaboration.

Key Words: Residential Construction, Education, Homebuilding, Residential Development

Introduction

Subprime mortgages, mortgage lending, green construction, LEED certification, market analysis, marketing, site selection, land development, construction software and networking applications, prefabricated trusses and wall panels, innovative building methods, value engineering, project controls and customer service, are just a few of the subjects major homebuilders must know well in order to have a successful business. Large homebuilders are no longer just builders of homes, they are developers of land, originators of mortgage loans, and sellers of real estate. The residential construction industry is an industry of constant change. How do educators prepare students for the construction industry when residential construction related courses are so scarce within construction education?

Residential construction capstone courses can be effective tools in exposing students to the unique aspects associated with the homebuilding and multifamily construction industry. Developing a residential construction capstone class can be a complex endeavor for instructors. Decisions must be made about the structure of the course, the content, the class projects, industry involvement, evaluation and grading policies, and student group arrangements. Instructors must also choose whether the course should be solely project based, theory based, or a combination of both. This paper discusses a residential construction capstone course pedagogy implemented at Texas A&M University, Department of Construction Science, that offers a balance of theoretical and experiential content.

One basic question that construction academics must consider is whether application based teaching methods are effective or necessary in university curriculum. Bernold (2005) boldly asserted engineering education must reform itself in order to accommodate an overwhelming number of creative students who do not learn well with the traditional pedagogical format of lectures, homework and tests. In his article, he provided a historical perspective by describing the educational philosophy of Alexander Meiklejohn, a strong voice in the 1930's speaking out against the commercialization of universities. Bernold explained how Meiklejohn's supporters felt the "'departmentalized university' was instruction, not learning centered, thus inhibiting the use of educational methods that stimulate student learning." The study examined topics including the failing education reform of the 1990s, substituting fixed course plans and lectures with learning communities, weeding out classes versus coaching classes, accommodating teaching around the learning cycle, and studies of engineering students study habits and skills. In conclusion, Bernold explained how two key questions needed to be addressed by educators: "What changes are necessary to create a community based teaching environment that allows each student to actively engage in a holistic learning process, and how can we empower our students to excel within such a drastically different educational paradigm." This study emphasized the importance of incorporating alternative forms of education to better teach multiple student learning types.

Various methodologies have been implemented in the past to inject application based curriculum into university level courses. Senior (1998) discussed different practical components that could be infused in construction courses such as simulation and gaming, case-based instruction, internships, service learning, field visits, and application papers. He provided a review of related literature for the each of the aforementioned practical elements. Senior concluded that more practice oriented curricula will be the norm and not the exception in future construction education.

Since this paper concerns an industry sponsored project, it is appropriate to examine academic literature related to project based learning. Chinowsky, Brown, Szajnman & Realph (2006) described a pedagogical approach to teaching civil engineering courses based on projects rather than lectures. The article initially discussed five alternative approaches utilized in construction education: the traditional approach, integrated engineering curriculum, the model approach, the case study approach, and the non-civil engineering approach. Chinowsky, et al. then introduced the project based learning (PBL) approach to construction curriculum. To validate course effectiveness, the authors conducted a study which involved follow up interviews with participating students, their employers, and faculty members within the university. The questions specifically addressed employment opportunities, subject understanding and domain understanding. Of the 24 students that graduated having experienced the PBL course, all believed their ability to communicate their PBL experience to potential employers provided them with an advantage in obtaining employment. Six personnel directors of corresponding employers were interviewed and stated that they believed the PBL graduates were more mature, better communicators, and had a greater understanding of working with clients. University faculty members commented on the students' ability to form questions that extended beyond the normal boundaries of an assignment. Every student interviewed either agreed or strongly agreed they gained a deeper understanding of the construction industry. In conclusion, Chinowsky, et al. highlighted two advantages of project based learning are that educators have the "opportunity

to expand beyond a knowledge point concentration" and that students have the "opportunity to explore problems that encourage skills beyond traditional analytic intelligence." This study did not adequately validate assertions made through rigorous quantitative analysis, however it provided relevant discussion points emphasizing the importance of incorporating project based learning into construction curriculum.

Albano and Salazar (1998) explained a project based graduate course entitled "Integration of Design and Construction" offered during the Fall semesters of 1995 and 1996 in the Department of Civil Engineering at Worcester Polytechnic Institute. The goal of the course was "to provide a project-based, practice-oriented opportunity for teams of students to deal with the problems of functional integration." The course pedagogy integrated class discussion, laboratory, and lecture activities as well as a real world project provided by industry participants. Student performance and feedback were used to validate the value of the course and to help with adjustments in curriculum content. The effectiveness of the course was not supported by related data. The integrated and collaborative design of this course is similar to the one described in this paper, but is applied to design and construction projects.

Several peer reviewed articles have specifically examined construction and engineering capstone course pedagogy and effectiveness. Todd and Magleby (2005) presented a case study for developing a two-semester senior design capstone course at Brigham Young University. The study discussed the importance of identifying and meeting the needs of various stakeholders including students, faculty, academic administrators, and industry. Conceptual models for capstone programs, program design considerations, and a case study made up key sections of the article. Todd and Magleby included data related to feedback from alumni and found that the capstone class ranked number one within the department's course offerings for its usefulness in preparing them for their careers as practicing engineers. This article provides a detailed and useful overview of important items to consider in the process of creating a capstone course.

Massie and Massie (2006) outlined a method that can be used in organizing student teams for capstone design and build group projects. Their article introduced the Team Project Document (TPD) that can be used by students and faculty advisors to establish goals and objectives and to facilitate communication among team members. The TPD was modeled from the United States Army's Officer Evaluation Report Support Form (OERSF), which was "designed to foster the communication process between senior and junior officers." Massie and Massie included a case study in which he TPD was used by students and faculty in the Sunrayce biennial intercollegiate competition to design, build, test, and race a car powered by solar energy. The team finished the race number 29 out of 29 teams racing. According to the authors, finishing last place may have been due to other externalities.

Paul (2005) provided a description of a Civil Engineering Design capstone course offered by the Department of Civil and Environmental Engineering at the University of Delaware. The article consisted of a historical course perspective, a course overview, and descriptions of fundamental course elements. The capstone course was a four credit course lasting two semesters. Approximately 55 senior level students were divided into four teams, separated by disciplines, to complete an actual project. The four teams were overseen by instructors who were practicing professionals. A full time faculty member managed and directed the course activities. Classes

consisted of lectures and team meetings. Major and minor deliverables were expected each semester. The major deliverable in the fall semester was a proposal to provide engineering services on the project, accompanied by an oral presentation. The major deliverable for the spring semester was an engineering report, also accompanied by an oral presentation. One quarter of each student's grade was given by the instructor's evaluation of participation in team and discipline sessions, one quarter of the grade was given by the instructor's evaluation of each team's deliverables, and one half of the grade was given according to the team's peer evaluations. The involvement of an instructor as well as multiple industry professionals who meet regularly with student teams appears to be an effective capstone format, but may be difficult to coordinate for many colleges and universities isolated from major populations.

Academic literature related to capstone courses and practical elements in construction education is abundant. The peer reviewed articles offer tremendous insight and applicable strategies for capstone course design. At the same time, there are methodologies that appear less effective. A consistent theme throughout the literature is that course pedagogy is constantly being altered, tested, and refined.

Course Overview

The residential capstone course at Texas A&M University, Department of Construction Science, is a three credit hour senior level course designed for students preparing to enter the homebuilding or multifamily construction industry. It specifically focuses on project management and exposes students to market analysis, site analysis, land development, residential design, building codes and entitlements, estimating, scheduling, financing, subcontracting, marketing, site management, business planning and current trends in design and construction. The intent of the course is to provide students a broad perspective of the residential development and construction process as viewed by production homebuilders and multifamily developers and builders. Expected core competencies for students completing the course have been outlined through nine learning objectives which are listed below in Table 1.

Table 1

Course Objectives

1. Understand and apply the fundamental concepts necessary to analyze a region for its housing market potential
2. Know how to apply the key decision variables in analyzing and developing sites for optimum housing layout
3. Understand the principles and procedures of housing design
4. Be familiar with residential building codes, their origin, and their application
5. Understand and apply common financing options for residential projects
6. Demonstrate knowledge of estimating, scheduling, and project planning procedures for residential projects
7. Be familiar with residential contracting and subcontracting, and documentation procedures
8. Understand and demonstrate residential project marketing techniques and principles

9. Understand the global economy's impact on U.S. homebuilders

The three credit hour course content consists of lectures, assignments, quizzes, exams and a semester project. Sixty-five percent of the grading is based on theoretical content and thirty-five percent is concerned with the experiential based semester project. The grading policy is listed below in Table 2.

Table 2

Grading Policy

Course Tasks	**Percentage of Total Grade**
Assignments	25
Quizzes	10
Exams (2)	30
Project*	35
Written – 30 percent of project grade	
Oral – 5 percent of project grade	
*Peer evaluation applied to overall project grade	
Total	100

Theoretical Course Components

The residential capstone course introduces students to development and construction terminology and theory through lectures, guest lectures, readings, assignments, and site visits. Evaluation of the theory component of the class is based primarily on individual performance as exhibited through assignments, quizzes, and exams.

Lectures and Guest Lectures

Course lectures are given by the professor and by guest lecturers from the residential construction industry. Lectures are designed to expose students to the theory behind topics they will be expected to incorporate in their semester project. These topics are pertinent to current homebuilding and multifamily construction trends. Topics include the history of homebuilding, market analysis, master planning of communities, site analysis, land development, the process of homebuilding, estimating, scheduling, financial analysis, project management planning, building codes and entitlements, marketing planning, customer service, alternative construction systems, and sustainable construction and development. Industry sponsors typically provide several speakers to explain different components of the construction process such as estimating, scheduling, land development, and value engineering.

Reading, Assignments, and Site Visits

Two textbooks are required for the residential capstone course. They include a land development book and a residential construction materials and methods book. Readings are assigned to correspond with lectures. The land development book explains the basics of market analysis, site analysis, entitlements and government regulations, site planning, environmental issues, and other land development topics. The residential construction textbook explains construction terminology as well as building materials and methods.

Students are given assignments with the goal of theory application. Assignments include required readings, writing tasks, and oral presentations. One assignment given to students each semester is to propose a location for the development and construction of 50 homes priced between 100,000 and 150,000 dollars within the state of Texas. Students are required to perform market analysis in justifying their recommended city and submarket. Students prepare an executive summary explaining their recommendation with copies of supporting data. They present their findings to the class as well. The class then votes on which city they feel would best accommodate the development. As a result of the assignment, the students have been introduced to researching demographics, economic characteristics, and psychographics of cities.

Site visits expose students to actual homebuilding processes they may have only read about in textbooks. The goal of visiting sites is to show students various stages of the construction process. Selected sites typically have several houses under construction at different phases of completion. Students can see pre-slab sites, sites with concrete slabs, sites with exposed framing, dried in homes, and model homes. Site visits to production homes, high end custom homes, apartment complexes, town homes, high rise apartments, and condominiums can provide students with a glimpse of the diversity of product types within the homebuilding industry.

Grading Policy of Theoretical Components

The grading system for the theoretical components of the course aims for the assessment of individual performance. 65 percent of each student's grade is comprised of assignments, quizzes, and exams. Assignments account for 25 percent of the final grade. In class quizzes account for 10 percent of the final grade. There are approximately five quizzes a semester, typically administered at the end of class, incorporating the material covered that day. Depending on how many quizzes are given, one or two quiz grades are able to be dropped by students. These quizzes provide incentive for class participation and attendance. Two exams are given each semester and are each worth 15 percent of the semester grade. The test questions are derived from lecture materials, guest lecture content, textbook readings, and site visit details. Exams provide incentive for students to perform their required readings and to be active within the class activities. The exams most often are multiple choice exams consisting of thirty to forty questions.

Experiential Course Component

Each semester the residential capstone class is given the assignment of creating a development proposal from start to finish. The proposal must contain a market analysis, a preliminary site design, a financial feasibility study, residential designs, a development estimate, a construction

estimate, a project schedule, a project management plan, an explanation of entitlements and regulatory issues, a marketing strategy, a customer satisfaction strategy, and an executive summary. An industry sponsor contributes basic project details from developments they have constructed, including site locations and housing designs, and assists student teams through guest lectures, site visits, and direct correspondence. Past industry sponsors have been DR Horton Incorporated, Stylecraft Builders Incorporated, and the Hanover Company. Residential unit types have included single family homes and apartment complexes.

For several semesters, students were divided into groups of three to four members and given the task of preparing an entire development proposal. Classes ranged in size from 15 to 39 students and yielded five to thirteen separate projects. The small size of the groups gave students good exposure to interdisciplinary components of a development plan. However, the projects were not very detailed and accurate due to the large amount of data and analysis necessary to complete such a project. As a result, the course project was adjusted by assigning groups of students to produce specific sections of the proposal. One group of students was given the task of overseeing the cohesiveness, design and formatting of the project. The entire class was responsible for creating one development plan. The goal of these changes was to produce a more detailed and comprehensive finished product.

Grading Policy of Experiential Component

The project grade accounts for thirty five percent of the semester grade. It is comprised of a written development plan grade worth 30 percent and an oral presentation grade worth five percent of the project grade. Peer reviews are conducted and can affect each student's project grade. Industry sponsors are asked to participate in evaluating the development proposals and presentations.

Evaluation of the written project involves grading each section independently and then averaging the section grades to obtain an overall written grade. Attention to detail, creativity, accuracy, and exhaustive work related to each project category are criteria for grading.

For the oral presentation grade, students are evaluated on their effectiveness in conveying necessary project information to the audience. They are also graded on their ability to answer questions posed to them. The oral presentation is expected to be a summary of the written project. It is important for team members to choose wisely what information they feel should be emphasized during this phase of the project.

Students are required to submit a peer evaluation for each team member based on a 1-100 percent scale. These grades are averaged for each team member and applied to the overall project grade. For instance, if John Doe's team earned an overall project grade of 100 percent and his personal peer reviews were 90 percent and 100 percent, Mr. Doe's project grade would be 95 percent.

Conclusion

Residential construction capstone courses for graduating college seniors are excellent venues for combining theoretical and experiential based curriculum pedagogy. Students enrolled in these courses have had years of experience in memorizing and reciting terminology and theory and are a semester away from starting their construction careers. The capstone course can play an important role in helping facilitate the transition from academia to industry by exposing students to actual projects and industry professionals while still in the classroom.

Finding the correct balance of theoretical and practical components for the course can be a difficult pursuit. It is easy to overwhelm students with too much theory while at the same time expecting them to complete a large project. Without classroom structure and theory, students may lose interest, motivation and perform poorly.

Important decisions affecting the dynamics of a capstone class are the size of student groups and the scope of work required from each group. Smaller sized groups tend to increase the accountability among members in performing their share of tasks. Student teams are required to complete their own project or take responsibility for a specific portion of the overall project. With large projects, it may be best to divide them into parts and assign those parts to specific student teams. As a result the entire class will work together to produce a well detailed project.

The success of a capstone course with industry collaboration depends on the proper selection of industry sponsors. It is important to select a sponsor who has the time, passion, and resources to contribute to the class. Collaboration with industry through the capstone course not only benefits the students, but also the academic program and the industry participants. Academic programs benefit by developing stronger relationships with industry members. Industry sponsors can benefit by having direct access to a pool of potential employees.

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