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Vertically Integrating a Capstone Experience: A Case Study for a New Strategy

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Global complexity is forcing a modification in project management from a typical task management approach toward a people management approach. Achieving success in complex projects is becoming more a matter of implementing people management linked to project task management. Construction education is involved in teaching project management and uses teaming in capstone simulations as a teaching strategy. A new strategy of teaching a capstone course involves vertically integrating upper and lower division undergraduates into senior led teams. This course teams sophomores, juniors, and seniors into a senior directed enterprise with the objectives of developing critical thinking, leadership and communication skills. The concepts and strategy for incorporating vertical integration is expressed in the context of a common course with varying experience levels and varying task assignments creating varying outcomes. The concepts of team formation, lead and support faculty, and leadership readiness matching are presented in detail. The internal structures and collaboration strategies are also presented. Student evaluations, assessment tools and course policy guidelines are described.

Key Words: Capstone Course; Construction Education; Undergraduate Curriculum; Course Integration; Project Management; Teams; Team Building; Vertical Integration; People Management; Situational Leadership

Introduction

Construction education programs frequently utilize a senior level capstone course as a finale to a student's academic development. The purposes of capstone courses are multi-fold with each program approaching them differently. Many of these programs use the concept of a project simulation involving student teams in company and job organization, bidding and award simulation followed by simulating the construction process through planning, scheduling, construction and close-out.

Among the goals and objectives of the capstone experience is to give students an opportunity to demonstrate the breath of their learning while instilling a sense of confidence prior to beginning professional careers. The learning objectives of honing previously learned skills and developing new skills focuses on team problem solving experiences. This is intended to establish the foundation for organizational and procedural understanding in project management.

The significance of a capstone course is that it merges participatory learning with academic inquiry and allows student interaction in a simulated environment organized around activities that require rigid procedures and processes in addition to unique and creative solutions. The typical construction capstone course is team structured and focused toward construction

organizations, procedures and operations. Many alumni comment that the simulated capstone experience was the most beneficial course of their collegiate career. These courses typically stand-alone and are composed entirely of seniors. The implementation of an integrated, lower and upper division, capstone course is rare. Integrated senior capstone courses have been discussed in the literature as a pedagogical strategy stressing participatory learning and creative problem solving. (Lonsdale, Mylrea, and Ostheimer, 1995)

The Building Construction Department at Virginia Tech has been engaged in curriculum integration and began a curriculum restructure in 1995. Incorporated into this restructuring is a revision to the capstone course creating a vertically integrated course. Rounds (1992) recognized that construction programs can be leaders of educational change and that team integration is a reflection of the realities of the construction industry. Improving the capstone experience by modifying the focus from project management to people management using teaming skills for self-directed actualization is one of the department's goals. An overall pedagogy for the department's curriculum restructure is described by Mills, Auchey, Beliveau, (1997).

Vertical Integration

One of the motivations for vertical integration was necessitated by a need for integrated student/ faculty contact throughout the curriculum and a desire to holistically improve student communication, leadership and people skills. The ultimate goals of the curriculum and the integration are to foster critical thinking, "out of the box" problem solving," and improved decision-making. One of the outcomes of this strategy is the development of a vertically integrated laboratory experience with common participation by sophomores, juniors, and seniors. This lab is intended specifically for construction undergraduates and occurs during a common period to allow all students to participate. Students of varying skill levels participate in responsible roles involving student led interactive team learning. Therefore the goal of vertical integration is for seniors to facilitate the learning process thus enhancing the student facilitator and other students learning by teaching and team building. The immediate objectives are:

- Recognition and capitalization on varying student skill levels to teach management, leadership, and team building skills.
- Development of an improved and integrated faculty/student team teaching concept.
- Improved communication skills among faculty and students to prevent dis-jointed teaching approaches. (Mills, Auchey, Beliveau, 1997)

The significance of this approach is that it moves away from the capstone "project management" approach and into an interdisciplinary "people management" approach. As a simulation technique this is more realistic involving multiple participants with separate agendas and goals striving to manage not only the technical aspects a project but also the diverse people and resources that create the construction. There is only one certainty in Pick up most any text on construction and/or project management and immediately the emphasis is on technical, procedural and process solutions to the enterprise. How many construction management texts fail to grasp the essence of the top skills needed by future constructors? Additionally how many

construction departments or programs are proactively structuring a curriculum to addresses the creation of leaders and not managers?

The need to be social constructor's first and physical managers second is increasingly being recognized. Using an industry survey, Mead and Gehrig, 1995 identify the top three skills needed by future constructors as communication, business management, and leadership. Andersen and Andersen, 1992 has identified that the construction industry must become proactive in its efforts to implement and manage the change from a "project system" to a "people system." A major role of a university environment is to contribute a legacy of individuals, who understand people, understand motivation and communicate as leaders in a continually competitive and changing world.

The challenge to university construction programs is shall they take the less risky role of creating project managers or encourage "out of the box" thinking to create visionary leaders of the construction enterprise. We need both, but a leader is able to develop managerial talents easier than a manager can rise to the uncharted roles of leadership. Dingle's "Project Management, Orientation for Decision Makers" addresses early on a need to understand the culture of an organization and the distinctions between managers and leaders. "Leaders are said to be innovators, while managers are optimizers. Leaders seek change, which they see as improvement. Managers aim for continuity. Leaders strive in circumstances of ambiguity, uncertainty, rapid change, and risk Managers strive for stability…" (Dingle, 1997)

Using Dingle as a model for teaching within a leadership environment necessitates a curriculum that creates open-ended problem sets that contain elements of "ambiguity, uncertainty, rapid change and risk." This is the world constructor's strive to tame. The only certainty in project management is uncertainty. (Forsberg, Mooz, & Cotterman, 1996)

The difficulty to university faculty in using this approach is developing readiness skills for both faculty and students. This is not a one-course solution but a focus for curriculum development that reaches maturity at a senior capstone course. Virginia Tech is working to create the leaders of the construction enterprise and is developing the concept of an cross curriculum integrated lab that stresses people skills, directed toward team building, communications, management, decision-making and leadership.

The focus of this as a senior capstone is that the seniors are the leaders of lower division students and mentors this group into a motivated and accomplished team of task managers. As the culture of integration grows so does the increased understanding and proactive contribution of the students involved supporting the success of integration.

Strategy for Integration

To develop an integrated lab experience requires a careful and detailed review of the curriculum. The investigation should reveal a structural model in which integration can or cannot occur. At Virginia Tech a "Learning Outcomes Template" or LOT was developed and used to facilitate the holistic systemization of the curriculum. This allowed a systematic approach and provided an

opportunity for altering the pedagogical model of the senior capstone course. (Auchey, Mills, Beliveau, Auchey, 1997) The transition of the capstone course from a "project management" approach to a broader "people management" and leadership approach is achievable with careful planning and dedication from faculty with similar pedagogy.

Organizational Structure

Within the department, faculty is able to schedule a common lab time and space for all second semester sophomores, juniors, and seniors to meet. It is essential to combine the classes at one time in one place for common team building activities and conflict free meeting times. The integrated lab course is a 3-hour, 1-credit course associated with a lecture/lab class referred to as the student's home course. The structuring of a course with distinct credit creates a struggle in establishing the meaningful link to the home course that a zero credit lab directly linked to the home course can retain.

Each of the home courses is consistent with the skill level of the student. The sophomores' home course is a 5-hr, 3-credit lecture/lab on Construction Principles, the aspects of estimating, planning, and scheduling of the means, methods and on the operations of construction covering CSI divisions 2-12. The junior home course is a 5-hr, 3-credit lecture/lab on Building Technology. This involves the construction of mechanical, electrical, plumbing, conveying systems, and special constructions, CSI divisions 13-16. The senior home course is a 5-hour, 4-credit lecture/lab with the internal lab component dedicated to a design-build activity. The 3-hour lecture component is used to develop support structures, critical discussion and preparation for the leadership and problem solving objectives being implemented within the integrated lab.

Organizational issues on scheduled meeting times are important in that a common time for discussion, assignments, feedback, and evaluation is necessary. With an experimental shift of emphasis from project management to people management and efforts to implement leadership skills within students, responsibility and authority must be delegated to the seniors. The seniors, who are essential to implementing the course, are quick to recognize that responsibility requires authority for success to occur.

Faculty Support

Faculty organization is established by having a single lead integration faculty with direct linkage back to the support faculty in the home courses. It is essential that the home course faculty be receptive to the intended objectives of the integrated lab. Acknowledgement of mutual faculty expectations and previous learning must be communicated amongst the faculty to remove any inconsistencies within the integration. In other words, the faculty or a core of faculty must be as integrated as the students are within the integrated lab. The role of faculty is dynamic in that the integrated lab has students with different skill sets and differing assignments that are woven into a whole.

The lead faculty of the integrated lab works in conjunction with the home faculty to develop the assignments and the learning outcomes. A primary role of the lead faculty is to provide the framework for team development. This is accomplished by guiding the growth of situational

team leadership from seniors who simply tell groups what to do, to participating in their task achievement, and finally into delegating responsibility, thereby allowing other students to make effective decisions (Hersey and Blanchard, 1993). The seniors are given the authority that allows them to develop leadership that builds their vision for success (Forsberg, Mooz, and Cotterman, 1996) aptly show a visualization of successful project management by piercing the holistic model of situational leadership with the linear model of task management.

An important aspect of faculty leadership success is oriented toward creating a ready and willing team of followers. Andersen and Andersen offer critical insight into the importance of "readiness" in securing productive and successful student participation and growth throughout the integration process. Leaders and managers must walk the fine line of giving a group or team more freedom than they are ready and willing to assume, least they become frustrated and discouraged (Andersen and Andersen, 1993). This is an equally important consideration in both the students to student mentoring and the lead faculty to seniors mentoring.

The great danger in working "outside the box" for a student and the lead faculty is that it's no longer safe. The ambiguity of the problem and the struggle to define management strategies for success are arduous for students familiar with distinctly defined rules that can be followed for measured success. The safe haven of success distinctly measured and awarded as grades is still a controlling motivator for most students. Many students fear uncertainty when ambiguity is used as a teaching strategy. Ultimately there is discovery that as leaders they must establish their own arena for learning and communicating responsibly to their teams.

The faculty role in the home course is to provide educational support that contributes to the student readiness. A fundamental aspect of successful leadership is recognizing the developmental level of each individual team member and matching that readiness level with a matching leadership style. The lead integration faculty will need to be cognizant of a student's readiness level and how a senior is matching this readiness with leadership. Andersen and Andersen (1993) provide excellent analyze of readiness and motivation with leadership match strategies, although their implementation focus is employee training. It is important in an educational context that faculty support the integration concept and allow issues developed and discovered in the integrated lab to be brought back into the home course for additional inquiry and learning.

Teaming Formation

The teaming format used within the integrated course is self established teams of sophomores, juniors and seniors. These teams are joined collaboratively to other teams either by choice or by assignment. The team structure is separate, yet collaborative, co-operative yet competitive. Each home course group is assembled into individual teams and these teams are then grouped with individual teams at the other two grade levels. These three teams then form a collaborative team with senior's providing guidance, mentoring and leadership.

One strategy that may be considered in teaming is the development of learning style evaluations of each student and then assign students to teams based on a diverse group of personalities and learning styles, or as was done in this case evaluations were completed and shared after teams

were established. This testing allowed students to recognize that not everyone is the same kind of learner. The need for different communication techniques to support academic security is shared with the students using alternative strategies to enhance their leadership skills and their team's development.

Internal Collaborative Teaming Structure

The internal focus for tasking has been based on a typical capstone simulation. The sophomores act as division 2-12 subcontractors and the juniors become subcontractors for divisions 13-16. The seniors act in the capacity of general contractors and or owners as necessary. Involving second and third year students with seniors allows each student to experience three different capstone projects. This provides the opportunity to use three different types of projects. The project selection is based on a small project that can be easily quantified and scheduled and rotates annually through industrial, commercial, and multi-family residential projects. During a four-year program each student is able to experience all three of these project types.

Each senior team is paired with one sophomore and one junior team. Team size is limited to 2-3 people on each team with a collaborative team of approximately 6-9 students. The assignments or problem sets are created around task commonly associated with a senior capstone course. Among these tasks are conceptual and detailed take-offs, planning and scheduling, company and project organization and financial analysis. The problems are distributed to the seniors who in turn restructure and delegate the task to the soph/jr teams. The first four weeks of the semester are spent in creating the team dynamics and working relationships. This time is used to produce the background material for the balance of the semester. The rest of the semester is spent in analysis, refinement and understanding the previous works relationship to the operations, production and management of construction. The particular assignments will vary depending on the type of projects, with the greatest difference in assignment types occurring in the residential development category.

Tasks are similar for each class level with differing levels of outcomes expected. Coupled with the previously described learning objectives more narrow and discrete task objectives are developed and proposed. These tasks are worked on incrementally over the duration of the course. The detailed learning objectives and task approaches of each distinct class are described and then a more detailed description of representative assignments is presented.

Sophomore and Junior Learning Objectives

- **Team Organization Strategies**
- **Improved Plan Reading & Specification Interaction**
  1. Scope Identification
  2. Detailed Estimate & Bid Submission
  3. Design/Construction Integration
  4. Value Engineering
  5. Pricing (Production rates and man hours)
  6. Execution Process
- **Production and Operational Management**
  1. Trades and Breakout of Scope
  2. Man hours/ Crew Makeup/ Leveling
  3. Productivity
  4. Schedule & Coordination
  5. Change Negotiation

Detailed description of task assignments used to reach the overall learning objectives for sophomores and juniors.

1. Acknowledgment of and participation in roles and responsibilities of team members.
2. Complete Estimate and Bid Proposal including General Conditions.
3. Development of a detailed computer schedule that can be collapsed into the senior produced master schedule. Schedule shall be resource and cost loaded for several discrete phases of the work (examples might be concrete, masonry and mechanical).
4. Written and CAD reports involving site utilization, hoisting, formwork design, embeds, and Mechanical Coordination Plans.
5. Decision-making and negotiating problems involving acceleration, changes in scope, cost of labor and time, increase productivity and/or corrective work issues.
6. A productivity improvement and/or value engineering solution.
7. Presentations and attendance at Presentations.

Seniors Learning Objectives

- **Teaming and communications**
    1. Team readiness preparation
    2. Owner/Contractor/subcontractor relationships
    3. Presentation Techniques
- **Mentoring**
- **Leadership**
    1. Pre-bid estimating/budgeting
    2. Scope Writing
    3. Bid review
    4. Personnel and Crew Motivation
- **Drawing & Specification interaction**
    1. General Requirements
    2. Staffing
    3. Payments and Change Order Management
    4. Control Techniques
- **Overall scheduling and coordination**

Following are basic description of task assignments used to reach the overall learning objectives for seniors.

1. Senior guidance in team organization and team roles and responsibilities. Senior development of a roles and responsibilities matrix for sophomores and juniors.
2. Scope packages and template development for estimates and sub-bid submissions.
3. A scoped conceptual estimate/budget that can be used as a "plug" for sophomore/junior team submissions.
4. Preparation by seniors of a master schedule for the Project. (Either P3 or MS Project). The Master Schedule shall allow roll-ins and is resource and cost loaded for all phases of the work.
5. An understanding of Project general requirements, cash flow, and staffing.
6. Guidance in developing written and graphic solutions for mechanical, formwork, hoisting, embeds, and site utilization.
7. Guidance in decision-making solutions involving productivity improvement on particular aspects of the Project.

8. Change order negotiations.
9. Presentations

Student Evaluation

Evaluation of students becomes a strategy in maintaining student motivation while exerting a focus on non-traditional formulas for demonstrative learning. The measure for the senior capstone students becomes how well they teach and learn. The value of grades as a measure of achievement forces many students into the tradition regurgitation model. What goes in comes out. This appears excellent for short-term measures of information gathering and retention but does little for synthesis of information and subsequent reflection and maturation of this synthesis.

When a problem set is broadly open-ended with varying levels of uncertainty, students may experience difficulty in determining how the outcome will be measured. Some students are slow to realize that it is their arena to create and they are establishing the rules. Faculty are faced with a dilemma of subjectivity evaluating individuals or teams based on their perceptions of the student or team as learners and responders of knowledge. The greatest challenge, in the development of an integrated course with varying skill levels and varying outcomes, is measuring individual performance as members of a team.

Several evaluation strategies have been used during the course. The initial strategy based on the lab being a part of the home course was to assign a percentage of the home course grade to the lab. This presented problems in that some students began doing the math on grading percentages. Depending on viewpoints this strategy is directed at maximizing productivity or as some students suggest, minimizing efforts. This created a mix of students not teams who were calculating how little or how much they had to do in the lab to achieve a particular grade in the home course. In addition, the outcome of problems sets ("inside the box" thinking), were given more weight by students then the developmental process of how well a student functioned and contributed in a team or how well leadership aspects and decision-making skills of team members were developed. Other concerns surfaced including which faculty would be providing the evaluation and exactly what criteria for evaluating abstract qualities such as leadership skills and appropriate decision-making would be used.

Student issues on student evaluations are always relevant and have been given due consideration. In the second year of the program, effort was directed at giving the lab a separate identity from the home course. This allowed a less challenging approach toward student evaluation but nullified the concepts of holistic integration among faculty and students and the home course. By creating a one-credit course the qualitative educational objectives became confused with the quantitative issues of a one-credit course. Simultaneous with the course credit transition was a restructuring of the grading criteria utilizing a holistic approach to student evaluation. Replacing the concept of A-F grading was a recognition of quality and not quantity of response. How much time spent on a problem or the course was not the measure. Achievement became acknowledged as the measure.

Achievement scales were established ranging from excellent to poor. Failure was not an option, though little understanding, failed accomplishment, or an absence of involvement could achieve it. A written criterion for each of the levels of achievement, excellent, good, fair, and poor were given to the students. Creativity, organization, interpretation, understanding, transition, timeliness, depth, detail and execution became points of discussion and foundation for evaluation. Periodic grading and feedback was done on completion of assignments, and evaluation discussions held on teaming, and leadership accomplishments. Peer evaluations were included in the holistic approach to grading student achievement. This contributed to easing the students' anguish over their perception of a less than totally objective faculty evaluation. The use of peer evaluations will increase. Even though there are shortcomings in peer evaluations, they are by and large valid and reliable evaluation tools. (Holland and Feigenbaum, 1998)

Opportunities for excellence were always open and intended to be viewed holistically upon completion of the course. Therefore a student who performed poorly on early problem sets (objective evaluations) could still achieve excellence at the completion of the course. Absent in the evaluation procedures was a completely balanced strategy to objectively grade abstract qualities of readiness, leadership, good decisions and team building skills. Research is underway to develop a consolidated evaluation strategy that balances subjective evaluations with aspects of objective evaluation. It's believed this will help students realize the importance of abstractions of knowledge and achievement as being self-defined and self-discovered concepts.

Assessment Tools

Course assessments are done at multiple levels with a university faculty/course evaluation completed by each student. Results of this evaluation are stratified. The sophomores and juniors rate the course and instructor fair, the seniors rate the course and instructor good. Additionally, seniors participate in an oral exit interview as members of their senior teams. This exit interview is intended to secure the students insights into the overall curriculum and their impressions on the integrated lab experience. The outcome of this evaluation of the integrated lab is that the strategy is beneficial but organizational and evaluation kinks need to be worked out to maintain a high level of student motivation. Sophomores are not formally interviewed.

Analysis

The strength of the integrated lab is that it structurally alters the typical capstone model away from task management and into people management. It initiates a different level of performance objectives that have removing ambiguity and uncertainty as their leading elements. This ambiguity and uncertainty highlights the fundamental aspects of risk so inherent in the construction arena. By allowing the students graduated access to self-managed and self-discovered leadership attributes the faculty is able to contribute successful problem solvers who can work "outside the box." These students are poised to take the reins of leadership and achieve success using people management to mitigate risk.

The challenge that must be overcome is the fear of failure by not following a formula that has been taught all one's life. This is true from both the faculty and the student standpoint. The formula of objective task management, and thoughtful risk shedding has long been touted as a formula for project management success. By taking a different path with potholes of ambiguity the participant have difficulty predicting the outcomes. Readiness preparation and understanding by the home and lead integration faculty are crucial to being able to present a course that tackles uncertainty head-on.

True project management success is derived from the decisions that are made by all the participants, down to the individual trades worker on a daily basis. By focusing on the people and encouraging self-management the attribute of success is identified as the reduction of uncertainty and the removal of ambiguity. It is the leader of the team that makes and reinforces this as the predicator of success.

Toward A Successful Capstone Integration

Successful integration requires a commitment to a long-term vision for what is internalized within the student. The goal of producing leaders in lieu of managers is primary. This vision guides the development of incorporating lower division students into the process as support personnel, followers and future leaders.

A consistent presentation of the learning goals and objectives across the curriculum creates support among the students. As the culture of the integrated lab grows so do the support and the anticipation of graduated levels of responsibility and authority. The ability to see the bigger picture of learning and differentiate it from the vehicle used to get there is a test of the successful management of the course. To improve the success and consistency of the course several components require implementation. Among the policies to internalize are:

- Establishment of clear performance activities.
- Establish what learning is to take place.
- Establish what knowledge is to be applied.
- Firmly establish the expectation on attendance and promptness.
- Consistent presentation of performance criteria that is consistent with the goals and distinct from the problem set solutions.
- A motivational strategy that reaches students with different skills and understandings.
- Student readiness preparation, across the curriculum.
- An on-time policy reinforced throughout the integration.
- Integrated faculty feedback and interaction.
- Formal peer evaluation across the internal teams.

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