

AC 2007-286: INNOVATIVE METRICS FOR ASSESSMENT OF A CAPSTONE COURSE IN A CONSTRUCTION MANAGEMENT CURRICULUM

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Abstract

Assessment methodologies that evaluate student development through demonstrated knowledge assure that student education is current, relevant, and comprehensive, thus meeting the needs of the industry, as well as, that of educational accreditation. However, if the educational assessment method is a comprehensive exam, or a portfolio, or an exit exam, there may be little difference in the demonstration of knowledge other than good examination preparation or good course work production even if a capstone course is used for the assessment purpose

This paper focuses on an innovative assessment method used in a capstone course. This method entails analyzing the management of a variety of construction projects by the student teams according to 13 different criteria and making presentations of their analysis and an overall summary statement. The presentations are evaluated by judges from the industry using the special metrics created for this purpose. Student performance is also incorporated as a metric in the assessment process. The paper elaborates on how student performance is affected by the different types of construction projects used as the “cases” by means of graphically displaying the metrics used and discussing their inter-relationships.

Introduction

University Engineering and Technology programs that assess student development through demonstrated knowledge ensure that student education is current, relevant, and comprehensive, to meet the needs of industry, as well as, that of educational accreditation. When students complete their education, there are a number of different ways to assess whether the students have actually learned how to articulate their knowledge, but a single methodology has not been universally agreed upon ^[1]. Standardized certification exams provide some independent method of assessment of student knowledge, but the results of the exams are generally not available for use in coursework. Capstone courses that aim to utilize competencies assimilated over four or more years of education are commonly used instead. However, if the educational assessment methodology used in such capstone courses is a comprehensive exam, portfolio, or even an exit exam, there may be little difference in the demonstration of knowledge other than good examination preparation or good coursework production ^[2]. Without a method to measure how well students demonstrate their range of technical knowledge, present their information and generalize these concepts within a team environment, assessment of real learning by the student does not meet the needs of industry or academia ^[3]. The method of assessment for the Construction Project Management capstone course used at the Purdue School of Engineering and Technology at Indiana University – Purdue University Indianapolis (IUPUI) is innovative because it measures the students’ integrated understanding of the primary topics directly related

to construction project management. The students are assessed on the breadth of their knowledge, and their ability to communicate a comprehensive plan for a construction project that they analyze throughout the course.

The use of a consistent method of assessment for a capstone course is valuable to demonstrate that learning occurs in the course to the same degree of expectation every semester the course is offered. By means of using a method of assessment that mirrors the processes of a construction project, industry needs can be met, as well as, the requirements for academic accreditation. If a multi-faceted method of assessment in a capstone course cannot demonstrate that the students have the ability to generalize and present their knowledge, industry may not have the confidence that their needs are being met^[3]. Hughes, Tippett and Thomas^[4] stated that project success can be measured using the elements of cost, schedule, scope, operating environment, safety, and quality. Through having an assessment-based scoring method that addresses these common construction project management issues, students receive validation on their generalization efforts with direct feedback about their team strengths and weaknesses.

Using different types of assessment tools is important to meet the universities' goal of providing qualified professionals that have applicable industry knowledge^[5]. This course incorporates the use of community projects along with practical applications of project identification, cost development, schedule management, risk assessment, and project administration. By using a graphic means to display relative strengths and weaknesses regarding thirteen categories of project work, students receive tangible feedback that they can use for improvement. Capstone courses commonly incorporate industry partners as part of the assessment undertaking to enhance the process. This paper also describes their involvement and displays their external assessment of the program results^{[2][5]}.

Course Goals

This specific construction project management capstone course has two sets of goals. The first set is specifically for IUPUI to meet three Principles of Undergraduate Learning (PUL). These goals are: 1) demonstrate the ability to express ideas and facts to others effectively in a variety of written formats, 2) demonstrate the ability to synthesize information in order to arrive at reasoned conclusions, 3) demonstrate adaptiveness by modifying one's approach to an issue or problem based upon the contexts and requirements of particular situations^[6].

Additionally, to assure that the Accreditation of Board for Engineering and Technology (ABET) objectives are addressed, the course is designed to meet five goals. These goals are: 1) demonstrate an appropriate mastery of knowledge, techniques, skills and modern tools of their disciplines, 2) function effectively on teams, 3) communicate effectively, 4) recognize the need for and possess the ability to pursue lifelong learning, and 5) understand professional ethical and social responsibilities^[7].

For their semester project, students work in self-selected teams using different sets of actual project plans to develop a "project action plan." They are assessed on this at the end of the semester through the use of a final presentation to a panel of judges from the industry. The

students also complete individual assignments each of which provides support documentation for the final presentation at the end of the semester. This paper describes the assessment methods implemented in the course and the outcomes from the presentations.

Project Variety

The projects that are used during a semester are different for each student team. Projects used include library projects, big box retail stores, fire stations, college dormitories, municipal offices and industrial buildings. The variety of projects, which range in value from \$1M to \$9M, allows each team to formulate their own information using the class lecture material as the conceptual basis for specific application to their project. A significant benefit for the students is that each project used in the course is an actual project that has been constructed. Since the projects are located within a reasonable distance of the University, students are encouraged to visit the projects to gain an understanding of the construction materials and details, surrounding areas, and limitations imposed by each specific location. This approach of using actual projects for teaching has been used with positive results by other educators as reported by Padmanabhan and Katti^[8], Holbert^[5] and Kerka^[3]. The variety of projects allows the students to apply the generic concepts taught in class to specific actually constructed projects. Productive class discussions occur on specific issues in relation to these projects which provide a practical medium for generalization of the project management concepts as an ancillary benefit.

Instructional Methodology

The specific instructional methodology employed is one that focuses on consolidating the engineering and management topics for the purpose of integrating technical issues with managerial issues. This approach has been used by educational institutions throughout the nation with demonstrated success^{[3][5][8]}. Students are challenged to understand that a reasoned, persuasive argument is imperative to being a skillful project manager. This is supported by research conducted by Pinto and Kharbanda^[9] that addressed the importance of achieving client satisfaction by taking a holistic view of project management by addressing human resource interaction and technical solutions. Through the use of lectures and in-class assignments, students practice writing introductory letters to participate in projects. They become aware of different roles and perspectives of the members of the construction development team in line with the diversity of project delivery methods. A key part of the capstone course is to review and define the risks associated with different projects and how contracting plans are driven by the different project types and their specific owners.

At the core of the class is the application of quantity and cost estimating, scheduling, and manpower allocation for different types of projects. It is through the use of these case-study projects that many of the students gain experience in solving technical and managerial problems that they encounter in completing the class assignments assigned to each project team. Project administration is addressed from the perspective of the “person in control of the process” a phrase used throughout the course to emphasize that there are many personal interactions within construction projects. This phrase is used to focus the student on achieving a logical and

comprehensive answer to questions that arise during a construction project. To implement this portion of the course, each team is tasked to develop a plausible company background that supports the competency of the team to complete the assigned project. As a part of this scenario, the teams define: core company competencies, field trade skills, site safety program, construction schedule management, subcontractor management, and cost forecasting, all of which support the course objectives for generalization of knowledge and targeted application of concepts learned throughout their education up to that point.

Presentation Criteria and Judging

At the end of the semester, the student teams are given an outline to be followed for their presentations that is in line with lecture materials and homework assignments. The premise of the presentation is that the team is a general contracting firm that has been selected as a finalist to present their contracting plan to a panel of owner representatives for the project. The goal of the presentation is to demonstrate knowledge of four primary areas of a construction project with subsections that address the specific technical and managerial project functions listed below. The outline of topics includes:

- A. Project Identification
 - a. Project Name
 - b. Owner
 - c. Location
- B. Project Scope
 - a. Type of construction
 - i. Materials types
 - ii. Primary structural and finish systems
 - b. Mechanical and Electrical systems
 - c. Contracting plan
 - i. Labor proclivity (union, or non-union)
 - ii. Self-performed work and why
 - iii. Subcontracted work and why
- C. Scheduling
 - a. Describe project schedule
 - b. Identify critical path activities
 - c. Discuss manpower loading and leveling options
- D. Project Administration
 - a. How will safety and OSHA requirements be addressed
 - b. Provide administration team organization
 - c. Review elements of project control system
 - d. Site layout and access control plan
 - e. Review conflict resolution strategy and proposal
 - f. Describe perceived risks
 - g. Prepare proposed schedule of values
 - h. Prepare and review project cash flow projections

E. Summary Statement of Qualifications

Each team presents their project information within the allotted 25 minutes followed by a 10 minute question and answer period with the judges. Each team uses at least two types of media which generally include a presentation slide show and information boards. Some even create business cards for their assumed company. The information boards are used to discuss specific topics as team members discuss their topics. Each team member self selects the topics he/she wants to discuss, but they are required to create a smooth transition between topics and project information. Students dress in business attire and are expected to present their information authoritatively addressing six story questions; who, what, when, where, why and how. The questions address the basic outline provided as a method to completely define and convey the relevance of their topic in the context of the overall project. While the presentation approach is commonly used for capstone courses^{[5][2][3]}, the specific method of measurement employed, in terms of five judges from the industry and academia asking the questions, enables the students to receive a detailed evaluation of their competence in the process. Two judges are from IUPUI and teach courses leading up to the capstone course. The benefit for the students and the judges is that while the material covered in the capstone presentation has been taught in earlier classes, the application of the concepts to a specific and different project demonstrates that the students have gained the proficiency of applying the knowledge in a practical way. The three remaining judges represent various segments of the construction industry. One is a general contractor, one is an architect, and the third is a mechanical or electrical contractor. Each judge receives instructions on the grading criteria and has a background in presentations to construction owners. The capstone course instructor acts as the timekeeper for the presentations but does not generally participate in the grading of the presentations. The diversity of the judges lends a good cross-section of the industry for the students because the questions from the judges cover the typical range of issues dealt with by the owners and the contractors.

Grading and Student Feedback

During the presentation, each team is graded by each judge using a five point Likert scoring scale on a form as shown in Figure 1. This scoring assesses the completeness of the coverage of the sixteen total topics, thirteen of which are primarily related to construction project management.

Project Review Topic	Topic Score					Question/Answer (Individual Student Evaluation)
Project Identification	1	2	3	4	5	
Project Scope	1	2	3	4	5	
Type of Construction	1	2	3	4	5	
Contracting Plan						
Labor Proclivity	1	2	3	4	5	
Self-Performed/Subcontracted Work	1	2	3	4	5	
Scheduling						
Describe Schedule	1	2	3	4	5	
Define Critical Path	1	2	3	4	5	
Discuss Manpower Leveling	1	2	3	4	5	
Project Administration						
Organization Chart	1	2	3	4	5	
Safety/OSHA Plan	1	2	3	4	5	
Conflict Resolution Plan	1	2	3	4	5	
Risk Assessment	1	2	3	4	5	
Project Finances						
Schedule of Values	1	2	3	4	5	
Cash Flow Projections	1	2	3	4	5	
Summary Statement	1	2	3	4	5	
Use of Visual Aids	1	2	3	4	5	
<i>Project Presentation Total</i>						

Figure 1. Presentation scoring sheet

Three of the criteria assess the project introduction, the use of visual aids, and the summary statement of qualification. The thirteen primary construction topics include:

1. Type of construction
2. Contracting plan
3. Labor Proclivity
4. Self/Sub work performance
5. Schedule
6. Critical path activities
7. Manpower allocation and leveling
8. Organization chart
9. Safety/OSHA plan
10. Conflict resolution
11. Risk Assessment
12. Schedule of values
13. Cash flow diagram

The assessment scores from each judge are then summarized in two ways to provide feedback to the students. The judging scores are graphed, and the scores for all criteria summed and averaged to determine the mean score for the total presentation. An example of the results is given in Table 1 which shows the distribution of scores among judges.

Table 1. Scoring summary for individual presentation.

Presentation Topic	Township Fire Station					Ave Score
	Judges					
	A	B	C	D	E	
Project Identification	2	5	4	4	3	3.6
Type of Construction	5	5	4	3	3	4
Contracting Plan	2	3	2	3	3	2.6
Labor Proclivity	3	4	1	4	3	3
Self-Perf./Subwork	2	4	4	3	4	3.4
Describe Schedule	2	4	4	2	3	3
Define Critical Path	2	4	3	4	4	3.4
Manpower Leveling	2	3	4	4	4	3.4
Organization Chart	3	5	4	3	4	3.8
Safety/OSHA Plan	4	4	3	4	5	4
Conflict Resolution Plan	2	3	3	4	4	3.2
Risk Assessment	4	3	4	4	4	3.8
Schedule of Values	4	4	4	5	4	4.2
Cash Flow Projections	5	5	4	5	4	4.6
Summary Statement	4	4	3	3	3	3.4
Use of Visual Aids	4	4	4	3	4	3.8
Criteria Total	50	64	55	58	59	
Ave Score		3.575				

The score for each judge is totaled for the complete presentation, but the overall presentation score is established by average of all scores. There is no weighting of the criteria to determine the final score, but this consideration is discussed in class. Each different project may have different primary drivers regarding scope, schedule, budget, and project administration and the stakeholders are the ones who determine the different levels of importance^{[9][4]}. For the purposes of this capstone course, however, there is no strong academic value for weighting the scores since the primary goal is to provide a comprehensive review of the project and synthesize all the relevant topics into the presentation.

Results and Outcomes

Figures 2 and 3 show the graphs of the scores for the presentations on a fire station project and a municipal garage. These graphs provide feedback to the students and the

instructor. First, the graphs depict the topics which the teams presented well by covering the topic exhaustively relative to the impact of this topic on the project. High scores are achieved through explaining the topic and relating the importance of that topic to other elements of the project. As an example, by discussing the interaction between critical path activities of the construction schedule and the cash flow of the project, a student can demonstrate that these activities are important to both the goals of the owner for on-time completion and for sound financial management of the project. Students receive copies of their results and can use them to assess their own performance based on the grade. Students are encouraged to use the results as a motivation for further learning and enhancing their proficiency of generalization as they enter their professional careers.

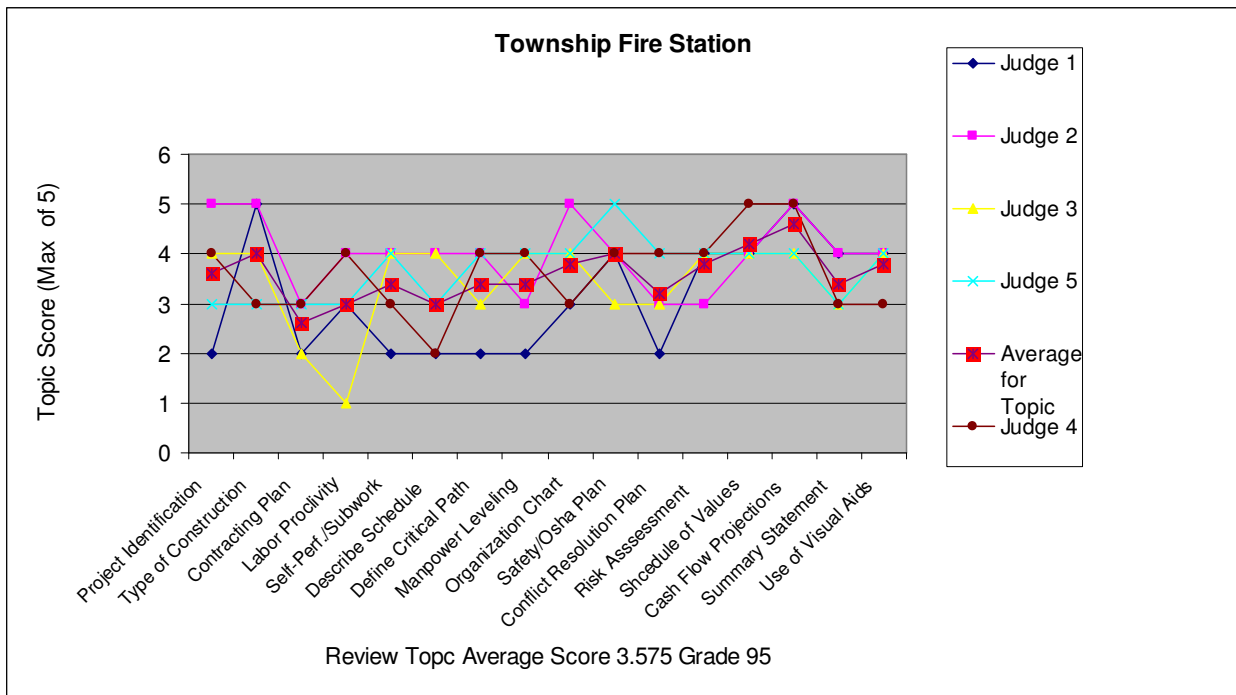


Figure 2. Township Fire Station scoring graph.

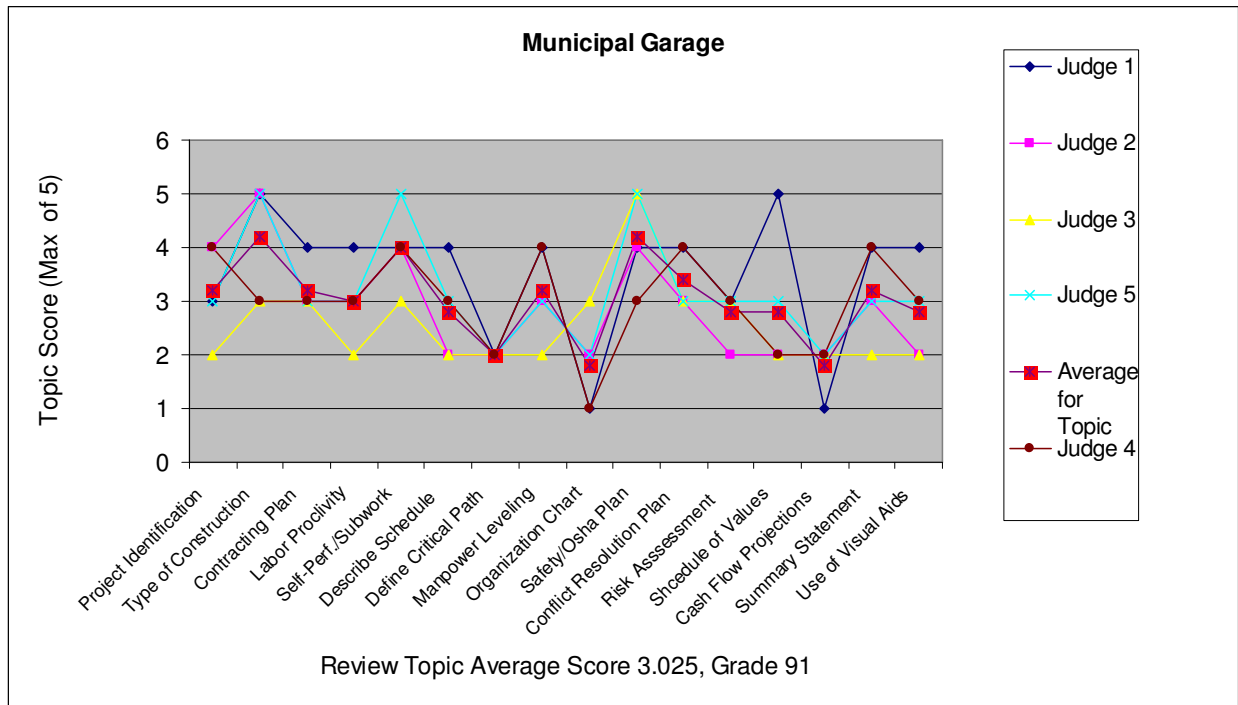


Figure 3. Municipal Garage scoring graph.

In addition, the graphs provide feedback to the instructor on the correlation between different project types and the subject matter for the course. The complexity of the projects vary among the project teams and thus some variation in scoring is expected between the projects. However, when individual topic scores are low across several project types, emphasis is added in future offerings of the course to clarify and relate this topic better to the larger context of project management. As an example one could look at Figures 2 and 3 for an understanding of concept of labor proclivity by the students. Labor proclivity discusses whether a project should be built using union or merit shop labor. In the two graphs used for this paper, scores trended lower on this item, therefore in subsequent offerings of the class, the topic of benefits and drawbacks of different kinds of labor involvement in construction work was covered in greater detail. Different project types are used throughout the course and different projects are used from one semester to the other. Currently there are nine different projects that are used in the course. Different projects are used from one semester to the other to vary the information used by the teams so that no two consecutive semester-project groupings are the same.

Conclusion

Capstone courses provide an efficient method of assimilating the previous individual course subject matters into a comprehensive undertaking as a way for students to learn. Through the use of actual project documentation, in conjunction with a coverage of project management theory, students learn to work in teams, focus generalize knowledge onto a specific project to which they have not been previously exposed, and complete the technical work associated with

construction project management. Rather than simply assessing the students' learning through the use of exams, students are exposed to external industry judges who provide a real and practical environment for measuring effectiveness and exhaustiveness of comprehensive project plans presented. Through the use of graphs to show strengths and weaknesses on team performance, students receive tangible feedback on their current skill levels and areas where life-long learning can be beneficial for improvement of such skills. This approach allows the students to more clearly understand that there is an important balance between technical skills and human resource interaction^[9]. As the industry changes, new projects will be added to this capstone course to provide current and relevant projects that continue to expose students to the state of the industry, while at the same time providing a realistic environment to achieve the academic goals of higher education strived for by the Purdue School of Engineering and Technology at Indiana University – Purdue University Indianapolis.

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