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Considering the Effectiveness of Comprehensive Assessment and the Impact of PBL Implementation in a Concrete Industry Project Management Course

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Considering the Effectiveness of Comprehensive Assessment and the Impact of PrBL Implementation in a Concrete Industry Project Management Course

The objectives of this study were two-fold: first, to assess the effectiveness of using Project Based Learning (PrBL) pedagogy and second, to determine the efficacy of a comprehensive set of assessment methods from the standpoint of assessing learning in a PrBL implementation. The project used in this study incorporates actual, in-the-field projects that represent real-life scenarios that the students will encounter once they graduate. Various direct assessment methods were implemented in this study. These assessment methods included a pre and post questionnaire of student beliefs and opinions, homework grades, in-class 'clicker' quiz grades, overall project grades, embedded test question grades, a video lecture project, and short answer case study questions on exams. The data sets collected with these assessment methods were compared to data taken from the past two offerings of the same course and with data from a similar course taught by the same professor in the same department. The analysis reshowed that the students favored both the actual concrete construction project and the milestone deliverable method. The particular assessment methods that provided the most feedback were the embedded test questions and the case study section of the exam. Since students had to work with an individual real-world case study on the exam, the individual student's effort, understanding, and ability to solve technical problems from the milestone project were quantified through the exam. The overall grade assessment method revealed an average of 4.5 percentage point increase in grades from past offerings of the course and a similar course that does not include the PrBL pedagogy.

1. Introduction

This paper reports on the third year of a Project Based Learning (PrBL) implementation in a project management course that is geared towards preparing students planning to work in technical positions in the concrete industry. This course is a junior level course that is required for all Concrete Industry Management (CIM) students; an undergraduate degree that is offered at Texas State University. The CIM degree is a construction management related degree that prepares technical managers for various functions in the cement and concrete industry. Over three offerings of this course, a PrBL method was employed utilizing a real world concrete construction project from a local construction company. Based on comprehensive assessments in the first two years of implementation, the course has evolved and is now better aligned to the principles of PrBL pedagogy and focused on improving student learning. The original study, which describes the development of the project used in the CIM course, can be found in reference 8, which was written and implemented by the authors of this paper. In order to determine the efficacy of the PrBL teaching method this study was developed and implemented using a repeated comparative research approach.

The assessment methods analyzed in this study as compared to past studies included both subjective (indirect) and objective (direct) measures. The indirect measure

included a pre and post questionnaire (before and after project experience) in which the wording was slightly modified based on the reflections of the instructor and informed by the continuous improvement process. Additionally, video lectures/documentaries of real-world construction projects were shown to the students followed by assessment of the students. Such assessments included a post-questionnaire that included assessment of learning outcomes and objective based questions, which were graded. The direct measures included homework grades, in-class 'clicker' quiz grades, overall project grades, embedded test question grades, and short answer case study questions on exams. The test questions included multiple-choice questions, true/false questions, and a realistic case study (short answer) section.

2. Background on Assessment Methods

In designing assessment methods to be used for evaluating learning that occurs in the context of PrBL it is useful to ponder on the skills, abilities and knowledge that we need to impart to future technical professionals from a technical project accomplishment standpoint. The following description from Savage et al[1] of engineering projects is very instructive. "For an engineer in industry, a project is a sequence of tasks required to reach an objective. Typically, the objective is to design a device or process that has value to a customer (user). The project begins by defining a performance problem associated with an application and ends with a design solution. The problem drives the learning required to complete the project. Managing the project requires the engineer to demonstrate effective teamwork, clear communication and the ability to balance the social, economic and environmental impacts of the project." This description provides us with a good sense of the attributes of a project or students' performance that need to be assessed.

Based on the foregoing, it would be important to bear in mind that in any PrBL based course, professors are mostly trying to assess learning in a practice-based or professional application context. This is in contrast to traditional modes of testing in academia that utilizes class tests, quizzes, homework and exams that tend to focus on the retention of specific technical principles, theories or other factual information[2]. Thus, there is a need to align learning outcomes, teaching and learning activities and assessment tasks. This is particularly so because pedagogies such as the PrBL have been adopted to encourage deep rather than surface level learning[3,4].

Literature on assessment of active learning is very heavily weighted toward problem based learning (PBL). However, since problem, enquiry and project based learning all share many similar characteristics such as being student centered, focused on deep learning, instruction being driven by a central problem or case and the instructor primarily facilitating the process of learning, the many methods listed for use with PBL should prove beneficial in the case of PrBL as well.

For project based activities to be truly effective, educators need to ensure that reflective learning is facilitated so that students can truly learn from the process[5]. Thus, assessment is an integral part of the learning cycle and occurs both during and at the completion of the project[6]. Instructors should plan for both formative and summative

assessment as part of the course. That is, they need to collect and act on information that will help students improve as they proceed, and they need to have measures that show what students learn overall. Evaluations should assess both individual and group work and represent multiple formats, such as written work (formal assignments and informal journal entries), observations (of group and individual activities), presentations, informal discussions and questions, and the final product[6]. The list of assessment methods from above provides a broad palette from which formative and summative methods may be adopted for use in PrBL. The portfolio method is widely used for PrBL because it includes the reflections of students for different periods, monitors improvement along the way, and documents the achievement of the prospective goal[7]. The following section presents a discussion of the assessment methods that were adopted for the current research.

3. Evolution of the Course and Details of Assessment Methods

The first author has taught the course in which this study took place since Fall 2013. The course is a Project Management and Scheduling course geared towards the concrete industry and is required for all junior leveled students. Since Fall 2013, the first author has been using PrBL pedagogy that utilizes a real-world case study involving concrete rehabilitation, in which the students are separated into groups and are asked to act as the General Contractor (GC) and bid the job. Each group is required to submit a bid package alongside a presentation of their bid given to the "owner", who is the professor of the course. The bid package is broken up into five 'milestones'; Soil Characteristics and Recommendation, Risk Assessment, Work Breakdown Structure (WBS), Estimate, and Schedule. These milestones are further detailed in reference 8. The same project and project requirements have been included in the course since Fall 2013, with only minor changes that were effected for purposes of clarity. In Fall 2015, additional assessment methods were introduced in the course, such that the efficacy of the PrBL could be comprehensively evaluated. For comparison purposes the assessment methods in the most recent offering of the course, were compared to those in the past offerings. Some assessment methods were compared to a similar course, which doesn't incorporate the PrBL project. The first author of this study also teaches a separate Project Management and Scheduling course to students in the Construction Science and Management (CSM) program. Most of the lectures and test questions were common to both courses, therefore the embedded test questions that were used to assess the PrBL pedagogy were compared across courses. Each assessment method is further outlined in the following sections.

3.1 Pre and Post Questionnaires

Pre and post questionnaires are a traditional assessment method used to gauge the impact of novel teaching methods. Although they provide quality feedback to the professor, the subjective nature of the questionnaires can be limiting, as not all students will response at the same level of openness. If questionnaires are used, it is best to make the questions as specific to the individual learning outcome as possible. As previously mentioned, pre and post questionnaires were used in previous iterations of this study. Additionally the new questionnaires have been categorized into four categories: A. Communication, B. Teamwork, C. Ethics and Professionalism, and D. Leadership. These four new categories

were selected as each category represents a desirable and employable work attribute. The questionnaire used a 5-point Likert scale in which 5 was 'Strongly Agree' and 1 was 'Strongly Disagree. The pre and post questionnaire questions can be found in the results section in Table 1 with a bar chart comparison of the results shown in Figure 2.

3.2 Documentary/Instructional Videos with Post Questionnaire

A video documentary related to construction practices particular to concrete pavement have been incorporated into the class. The video, which is entitled, "A Span In Time"[9] is of 45min duration and describes the construction, and replacement of the San Francisco- Oakland Bay Bridge. The material covered in the video reinforces material that was covered in the class including construction personnel, equipment, and practices, and other desirable soft attributes such as strong communication between partners, teamwork, ethics and professionalism, and leadership. The video was shown on the first day of class and was complemented by commentary provided by the professor before, during, and after the video was shown. During the video a pre-questionnaire that included both subjective and objective questions was provided to the students. For comparison purposes, the same video and the same questionnaire, now referred to as a post-questionnaire, was provided to the students near the end of the semester after all of the pertinent topics have been discussed in the course. The post documentary/instructional video questions can be seen in Table 2 along with the results in Section 4. A five point Likert scale was used to gauge the subjective based questions, in which 5 was 'Strongly Agree, and 1 was 'Strongly Disagree'.

3.3 Homework Grades, Overall Project Grades, and 'Clicker' Quiz Grades

As previously mentioned, a holistic assessment of new pedagogical methods should include both indirect and direct assessment. This section describes three different direct assessment methods used in this study. The first is the homework grades. As described in great detail in reference 8, the project used for this class is broken up into 5 'Milestone' deliverables. The course utilized a unique format in implementing the milestone deliverables such that each deliverable was due shortly after students received formal instruction on the topic in lecture sessions as well as delivering one final packet at the end of the semester, which included all deliverables. This method allowed each student team to get two attempts in accomplishing each deliverable. The milestone deliverable concept was developed and implemented in the Fall 2014 offering of this course; however, the grade comparison for assessing the impact is reported in this study for 2014 and 2015. In certain cases the students' were permitted up to three attempts at a specific topic, due to the importance of the specific topic. That is the students had both the project milestone grades, plus an additional individual homework assignment on the topic. This was implemented due to the importance of certain topics. It should be noted that, time constraints also factored into this decision. The specific milestone topics that had an additional individual homework assignment were the risk assessment topic and the scheduling topic. An individual assignment was provided to the students, in which they had to solve a network based schedule for a small warehouse, using the Critical Path Method (CPM). Subsequently, the students had to quantify the three types of float on each node. A comparison of the

homework versus the overall project grade can be seen in Figure 3 along with additional discussion in the results section.

In addition to the homework and overall project grades, the students were asked in-class 'clicker' questions related to each individual topic. To those not familiar with a 'clicker', this is a portable electronic device that each student purchases and brings to class. This type of involvement, promotes an active learning environment while simultaneously breaking up the monotony of a power point presentation. Therefore, 'clicker' based quiz questions were incorporated into each lecture in order to assess the students' understanding of each major topic. The questions were strictly objective, featuring either multiple choice or true/false based questions. A set of 2-5 questions were presented at the beginning of the lecture, before any content was presented, and the same questions were presented subsequently, either interspersed within the lecture or at the end of the presentation. This permits a before and after comparison of results. The rationale for asking the same questions interspersed within the lecture is to promote an active learning environment and thereby keep them engaged until the end of the lecture. This method also provided opportunities to discuss the results of the questions during the lecture as opposed to towards the end when time may be limited. The results for the clicker based assessment, broken up into the five milestone topics, can be found in the results section in Table 3.

3.4 Embedded Test Questions

An additional direct assessment method used in this study was embedded multiple choice and true/false test questions. Each offering of the course included three exams and a comprehensive final exam. These exams incorporated multiple questions that directly related to the five milestone objectives of the project. The questions relating to each topic have been grouped together and averaged per semester of the course offering (2013, 2014, and 2015). As previously mentioned, the first author of this study also teaches a separate construction management course geared towards construction majors, in which the PrBL method is not implemented, however, similar topics are taught and the same embedded test questions are used. Therefore, a comparison has also been made to the Spring 2014 and Spring 2015 Construction Science and Management (CSM) version of the course. The results and analysis of this assessment method can be seen in Figure 4, found in the results section.

3.5 Short Answer Case Study Test Questions

The last assessment method used in this study was a short answer case study test question added to each exam. As with the embedded test questions mentioned above, not all milestone objectives were made into a short answer case study, due to applicability and time constraints of the examination. Therefore only the Soil Characteristic, the Work Breakdown Structure (WBS), and the Scheduling milestones were assessed via the short answer case study assessment method. Depending upon when each topic was discussed in the semester, one of the three milestones was included at the end of each exam.

The Soil Characteristics short answer question was the following:
"The sub-grade soil on a project was found to contain a soil that is 85% within the MH group and 15% within the SP group. The boreholes show this soil to exist at a depth of approximately 8 – 15 ft throughout the footprint of the project. As a construction manager, one should understand whether the soil is acceptable to build on or if the soil needs to be replaced. If the soil needs to be replaced, please provide a description as to why you recommend replacing the soil, at what capacity (amount) you recommend replacing the soil, and what type/soil group do you recommend the soil to be replaced with." The students were provided a copy of the Unified Soil Classification System (USCS) data sheet during the exam, which was covered in the lectures.

The WBS short answer case study was as follows: "Use this paper to develop/draw a WBS for a 1500 ft² single-family residential home to be built in the local area. This home will be a 3 bedroom, 2.5 bath, 2 car garage, post tension foundation, and wood construction with a brick façade. Use your construction knowledge to 'breakdown' this project as much as possible being sure to group each item appropriately."

Lastly, the Scheduling short answer case study required the students to solve a pre-arranged, blank, network based schedule. The exact schedule used for this milestone is shown in Figure 1.
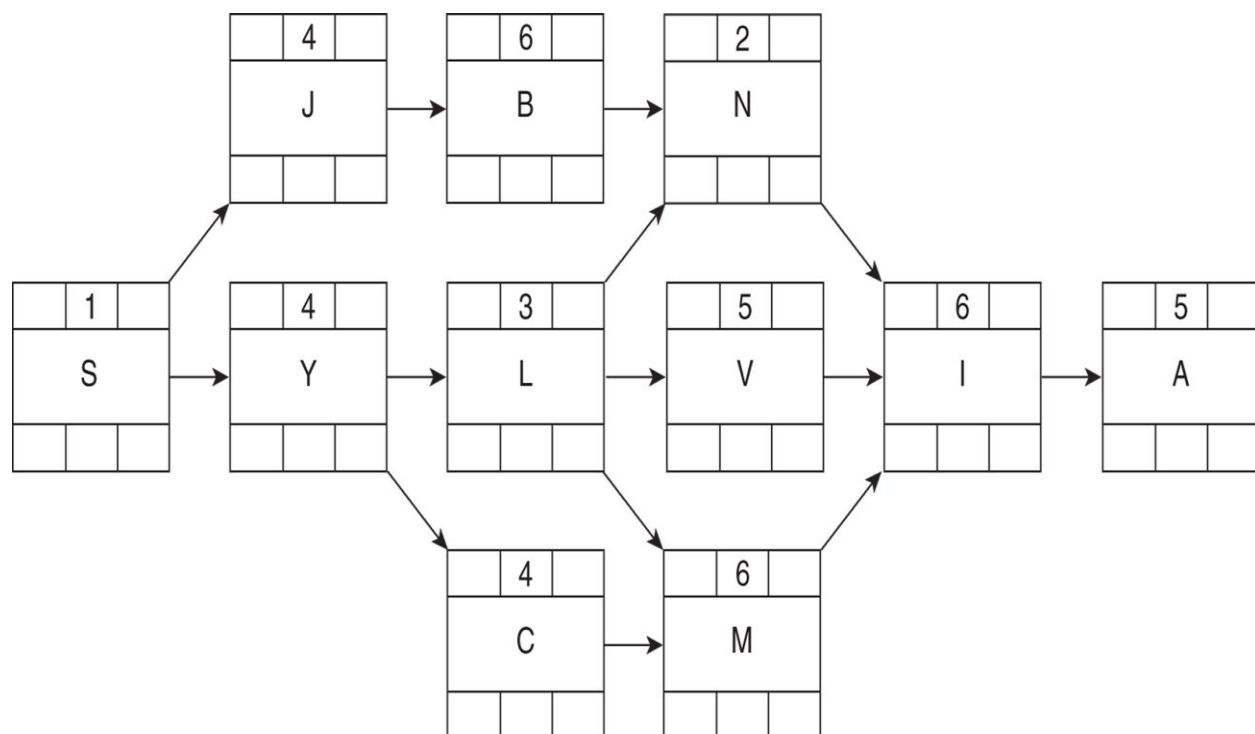

Figure 1: The network schedule used to assess the comprehension of the scheduling topic.

As shown in Figure 1, it can be seen that the network schedule is pre-arranged by indistinct nodes, however, the students are required to use the CPM to solve the schedule. The three short answer case study assessment method was a newly implemented assessment added

in the Spring 2015 semester, therefore, there is no direct comparison to be made from semester to semester. The newly added short answer case study questions were incorporated to strengthen the comprehension and understanding of the five milestone topics and the impact of the short answer case study assessment methods can only be inferred from the overall project grades from semester to semester.

4. Analysis and Results

4.1 Pre and Post Questionnaires

As previously described a pre and post questionnaire was provided to the students at the beginning and end of the course respectively. The current iteration of the course (Fall 2015) had minor modification of the previous iterations of the questionnaire. The new questions and their respective results can be found in Table 1 and Figure 2.

Table 1: Pre and post questionnaire analysis.

Pre-Analysis			Post-Analysis			
Course Outcomes	**Average**	**Percent In Favor**	**Course Outcomes**	**Average**	**Percent In Favor**	**Percent Improvement**
A. Communication						
Pre 1. I expect that my studies in this course will increase my ability to design and deliver effective presentations for a variety of audiences.	3.8	76.00%	**Post 1.** My studies in this course have increased my ability to design and deliver effective presentations for a variety of audiences.	4.6	92.00%	19.05%
Pre 2. I expect that my studies in this course will increase my ability to write in a clear, coherent, and professional manner.	2.8	56.00%	**Post 2.** My studies in this course have increased my ability to write in a clear, coherent, and professional manner.	4.2	84.00%	40.00%
B. Teamwork						
Pre 3. I expect the instructor and the experience of working on a team in this course to provide new insights or develop skills that will increase my ability to work effectively in a team environment.	3.2	64.00%	**Post 3.** The instructor and my experience in working on a team assignments in this course have provided new insights or skills that have increased my ability to work effectively in a team environment.	4.5	90.00%	33.77%
Pre 4. I expect to be able to work effectively in a team environment.	3.1	62.00%	**Post 4.** I was able to work effectively in a team environment.	4.1	82.00%	27.78%

|						
C. Ethics and Professionalism						
Pre 5. I understand the kinds of ethical concerns that I might come across in the context of the concrete industry.	3.8	76.00%	**Post 5.** I understand the kinds of ethical concerns that I might come across in the context of the concrete industry.	4.3	86.00%	12.35%
Pre 6. I feel well informed and empowered to act ethically and in a professional manner in the context of the concrete industry.	4.1	82.00%	**Post 6**. I feel well informed and empowered to act ethically and in a professional manner in the context of the concrete industry.	4.9	98.00%	17.78%
D. Leadership						
Pre 7. I understand the leadership function in the concrete industry professional organization.	3.8	76.00%	**Post 7.** I understand the leadership function in the concrete industry professional organization.	4.5	90.00%	16.87%
Pre 8. I feel well informed and capable of serving effectively in a professional leadership capacity.	2.8	56.00%	**Post 8.** I feel well informed and capable of serving effectively in a professional leadership capacity.	4.6	92.00%	48.65%
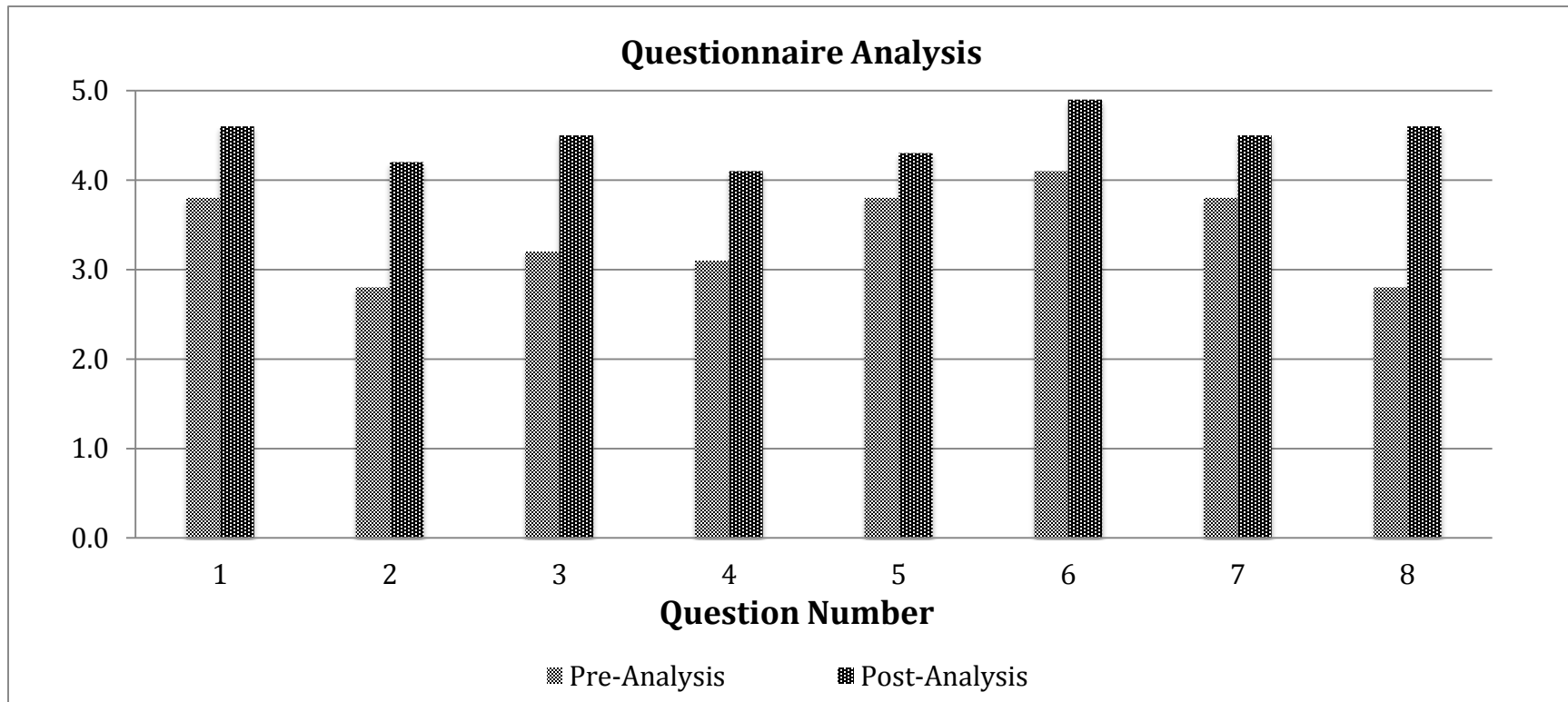
Figure 2: Pre and post questionnaire analysis result comparison.

As shown in Table 1 and Figure 2, there is improvement in every category, which is appropriate for a pre and post questionnaire assessment as the students are learning construction management practices. Observing the data, it is seen that both pre-questions 2 and 8 had the lowest score of 2.8 ("Disagree"), which also had the highest improvement in the post-questions, up to 4.2 and 4.6 respectively ("Agree"). Question 2 assessed the students' communication, with a specific emphasis on written communication. The lower score on the pre-questionnaire is believed to be due to a common misconception that writing is not a requirement of the class. However, written communication is a substantial requirement for all construction managers and is extensively covered in the course, which is why a high increase is observed in the questionnaire assessment. The top-performing question from the pre-questionnaire was question 6. Question 6 assessed the students' understanding of being able to act ethically and professionally in the construction industry. The pre-questionnaire results of question 6 displayed a result of 4.1 ("Agree"), which is an expected result as ethics is covered in many other earlier courses within the discipline. There was an increase of only 17.78% on question six, corresponding to a post analysis score of 4.9, which is almost a "Strongly Agree". This is a significant learning gain as ethics is very important for construction managers.

4.2 Documentary/Instructional Video with Post Questionnaire

The documentary/instructional video is a new assessment method added to this study that contains a pre and post questionnaire that includes both subjective and objective questions related to the video. The questions and results are found in Table 2.

Table 2: Documentary questionnaire questions and results.

Question	Early-Analysis		Late-Analysis		
	Average	Percent in Favor	Average	Percent in Favor	Percent Improvement
D1. I understand the role of a General Contractor (GC).	4.3	86%	5	100%	15.05%
D2. I know what a Joint Venture is.	2.8	56%	5	100%	56.41%
D3. I know the role of a Project Manager.	3.9	78%	4.8	96%	20.69%
D4. I understand the importance of effective communication on the job site.	4	80%	4.3	86%	7.23%
D5. I know the importance of a thorough soils analysis before construction begins.	3.2	64%	4.4	88%	31.58%
Question	**Average Percent Correct**		**Average Percent Correct**		**Percent Improvement**

D6. What was the name of the GC?	73%	95%	26.19%
D7. The superintendent was in charge of all the subcontractors? (T/F)	89%	100%	11.64%
D8. Who was the client/owner of the project?	82%	100%	19.78%
D9. What does USCS stand for?	55%	90%	48.28%
D10. What type of schedule was used?	75%	100%	28.57%

As shown in Table 2, it can be seen that 10 questions were asked such that the students were not overwhelmed with questions while watching the video. Half of the questions were opinion based; gauging the students' understanding of certain topics outlined in the video, whereas the other half were objective questions. As with the overall questionnaire discussed in the previous section, there was improvement with each question. Questions D1 and D2 increased to a 100% understanding of the topic. The lowest improved topic was question D4, in which the students' appeared to understand the importance of effective communication on the job site. There was also improvement in all objective questions, with three questions scoring a 100% in the late semester showing of the video. This is likely due to the fact that these topics are covered extensively throughout the semester. The question that scored the lowest was question D9, which was the definition of the USCS acronym. The lower than expected result was due to strict grading adopted by the professor. All four words had to be identified, spelled correctly, and in the correct tense. If a student defined the first "S" as Soils, then the answer was incorrect as the first "S" is not plural (i.e. Soil). After the questionnaire was graded and returned back to the students, the rationale for the strict grading was explained, as it is important to be precise when communicating in the construction industry.

4.3 Homework Grades, Overall Project Grades, and 'Clicker' Quiz Grades

One of the major assessment methods used in this study was to compare the grades of the individual milestones from the Spring 2014 semester to the Spring 2015 semester. As previously described each milestone allowed for at least two attempts; two of the milestones allowed for three attempts. The average grades for this assessment method can be seen in Figure 3.
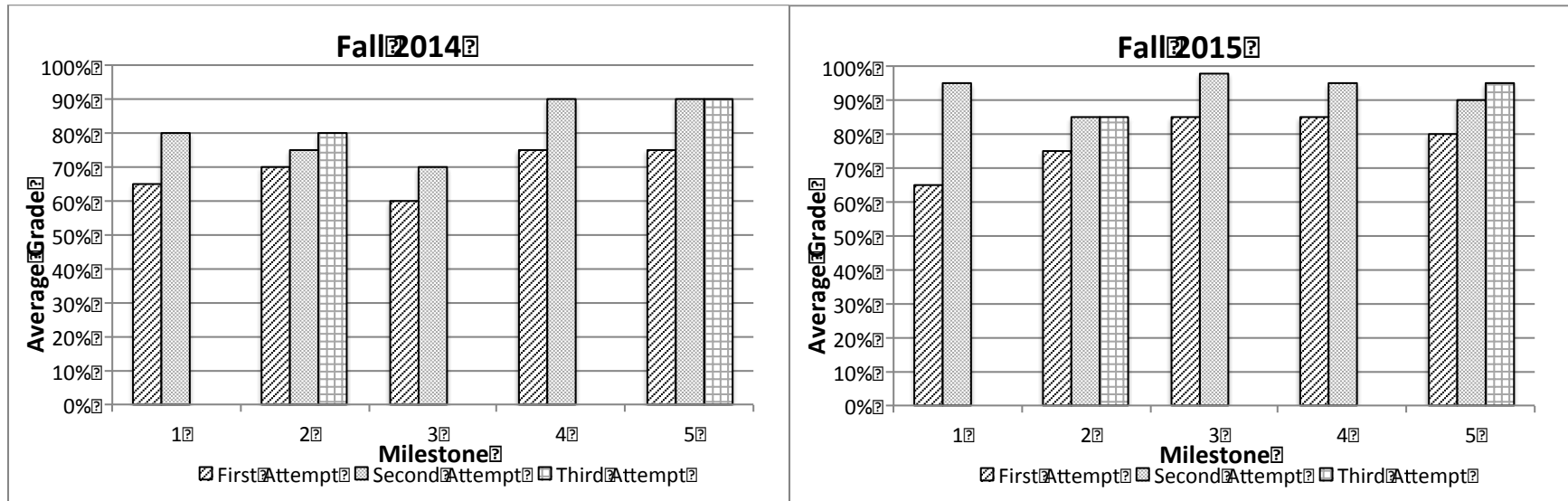
Figure 3: Fall 2014 and 2015 milestone grade comparison.

As pictured in Figure 3, it is clear that the multiple attempt deliverable method is an effective teaching tool. For a complicated project such as the one included in this study, it is beneficial to allow the students to have multiple attempts at each milestone with a lecture on the why and how of the correct and incorrect responses in between each milestone. It is also noticed that the two milestones (Risk Assessment and the Schedule) that offered three attempts either increased or remained the same. When comparing from semester to semester, it is clearly observed that the Spring 2015 semester out performed the Spring 2014 semester. This is believed to be due to the additional learning activities and assessment methods added that have an impact on the students learning and comprehension of the major topics, such as the instructional/documentary video and the short answer case study questions.

Another assessment method that was introduced in the Spring 2015 semester that may have had an impact on the increase in students' grades was the clicker quizzes before and after each lecture. As previously mentioned the students were given a clicker quiz before each milestone topic, then the lecture was provided, followed by the same clicker quiz. Often times the questions were given during the lecture, immediately following the specific topic, to promote an active learning environment. The results of each question have been averaged and categorized within the milestone deliverable topics and are shown in Table 3.

Table 3: Results of the Clicker quiz assessment method.

Milestone	Pre-Lecture Average Grade	Post-Lecture Average Grade
1. Soil Characteristics	30%	95%
2. Risk Assessment	85%	100%
3. WBS	75%	95%
4. Estimate	75%	100%
5. Schedule	70%	95%

As seen in Table 3, there is an improvement in each milestone topic, with the highest improvement occurring in milestone topic 1, Soil Characteristics. Throughout the CIM curriculum, there is no other class but this one that teaches the students the importance of the soils on which structures are built on, therefore the students are not familiar with soil based topics before the specific lecture. It is seen that the lowest average grade for the post-lecture is 95%. This degree of improvement is expected for this type of assessment method as the topics are fresh in the students' memory and some of the questions take place immediately following a similar example provided by the professor or owing to the fact that the definition was previously given. Overall, this assessment method provides quality feedback on the individual millstone topics immediately after they are taught.

4.4 Embedded Test Questions

An additional quantitative assessment method was the use of embedded test questions on three of the exams in both the CIM course in which the PrBL method was implemented and a CSM course in which the PrBL method was not implemented. Two semesters were investigated in this assessment method and the results can be seen in Figure 4.
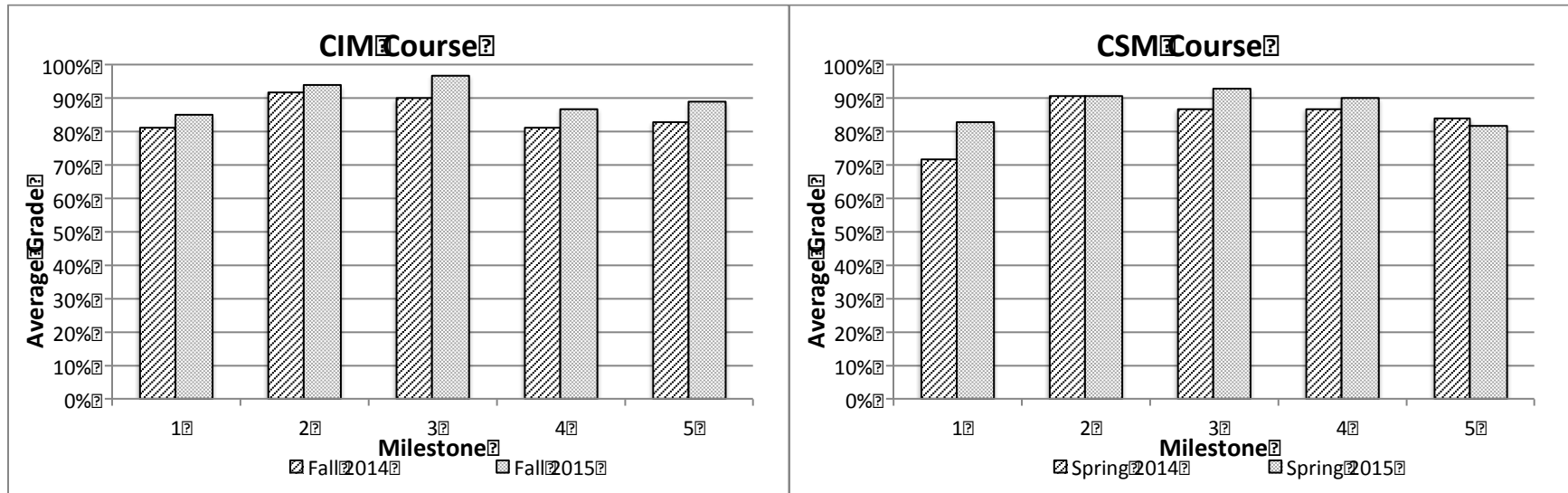
Figure 4: Embedded test question assessment comparison.

The results of the embedded test questions show the most beneficial information as this assessment method allows comparison of two semesters in two different courses, one with the PrBL method and one without. Overall, it is easy to see that the CIM course that implements the PrBL pedagogy scores higher on the same embedded test questions. Taking an average of all embedded test questions from the CIM course scores yielded an overall average of 88% as compared to an overall average of 86% for the CSM course. The only milestone category that the CSM course scored better in was the Estimating topic. The CSM majors have an entire course dedicated to Construction Estimating, whereas the CIM majors learn Estimating only in the course in which this study took place, therefore, it is expected that the CSM majors would fare well in this milestone. An additional benefit of this assessment method is that a semester-to-semester comparison can be made. It is observed that almost all of the average grades are higher in the second (latter) iteration of the study, with only one milestone topic that performed slightly lower in the second iteration. Averaging each semester reveals an average of 85% in Fall 2014 to an increase of 90% in Fall 2015 for the CIM course, whereas the CSM shows an average of 84% in Spring 2014 to an increase of 88% increase in Spring 2015, which is an overall average of 4.5 percentage point increase. As with the homework and overall grade assessment method, it is believed that the additional assessment methods such as the clicker quizzes and short answer case study questions had an impact on this result.

4.5 Short Answer Case Study Test Questions

The last assessment method used in this study was the use of short answer case study test questions added to the end of the exams. As previously described this assessment method does not have a direct comparison to an alternate semester or a pre or post offering of the method as it was the first time this method was used in the course. The impact of this assessment method can only be inferred through a comparison with the other assessment methods, which all show that the Fall 2015 scores are mostly higher than other offerings; likely due to the addition of the short answer case study test questions and other assessment methods. The results from the Fall 2015 short answer case study test questions can be seen in Table 4.

Table 4: Short answer case study test question assessment results.

	Average Grades
Milestone	Fall 2015
1. Soil Characteristics	95%
3. WBS	80%
5. Schedule	94%

Overall the results of this assessment method were favorable and provided good insight into the comprehension of student learning on the three milestone topics investigated. The results of the short answer case study test questions were a little lower than anticipated for the WBS topic, which was due to three students misunderstanding the question and actually producing a network based schedule. These three students received partial credit as their network schedules were very thorough and included most of the

required elements (activities) that would be included in a WBS, however, their grades still affected the average of that particular topic.

5. Conclusions

This study developed and implemented multiple assessment methods that consider the effectiveness of a PrBL pedagogy in a Construction Project Management course for three consecutive offerings. A total of five different assessment methods were used in this study, which all provided quality insight into the efficacy of the PrBL method employed. Each assessment provided a varying degree of insight, such that some were purely student based opinions and others strengthen the implementation effectiveness of the PrBL approach. With any assessment process, both direct and indirect assessment measures are essential. The inclusion of formative assessment along with summative assessment ensured that assessment occurs both during and at the completion of the process. In turn, this combination of formative and summative assessment helped to facilitate reflective learning. This study applied a varying degree of both measures. The particular assessment method that provided the most feedback was the embedded test questions and the case study section of the exam. Since the students had to work with an individual real-world case study in the exam, the individual student's effort, understanding, and ability to solve technical problems from the milestone project was quantified through the exam. The overall grade assessment method revealed an average of 4.5 percentage point increase in grades from past offerings of the course and in a comparison with a similar course that did not include the PrBL pedagogy. These results also demonstrate that the PrBL is an effective pedagogical approach that can promote deep comprehension of topics, while also promoting an active learning environment. Future implementations will consider including portfolios as a central and integrative assessment method because 'it includes the reflections of students for different periods, monitors improvement along the way, and documents the achievement of the prospective goal'.

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