New Orleans JAZZED about Engineering Education

Paper ID #15344

Using Blended Learning to Address Instructional Challenges in a Freshman Engineering Course

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Abstract

This study analyzed the role of *evidence-based instructional practices* in a blended course for a freshman engineering course. The instructor had been teaching this construction management class combining traditional lecturing and in-class discussions. The instructor sought to increase students' engagement with the material, each other, and himself as well as dedicate class time to active learning activities, higher order thinking skills, and application of concepts. The present research was conducted to explore blended course design in addressing the aforementioned instructional challenges. Blended learning is an instructional mode that combines substituting a significant portion of time spent in the classroom with online preparatory content and assessments. The online activities are then followed by a set of active learning activities that are thoughtfully integrated and involve assisting the learners in meeting the course objectives (Garrison & Vaughan, 2008; Glazer & Rhem, 2012).

Contemporary definitions of blended learning consider the rapid development of technology tools and the opportunities these tools provide to merge online and in-class instruction and learning activities. The thoughtful integration of face-to-face and online learning experiences in blended courses and its positive effects on students' performance, collaboration, and satisfaction with the instruction is well documented in literature. Instructors of engineering courses have documented and explored their experiences with blended learning and have reported positive outcomes: however, as blended learning gains momentum in STEM fields, it is essential to understand the freshman experiences and perspectives on blended delivery of content

as well as the role of blended learning in resolving instructional challenges commonly present in first year engineering classrooms.

To gather student perceptions, an anonymous survey was administered twice each year the course was taught: first during the fourth week of the semester and once again at the end of the course. Surveys gathered quantitative information from the students on time spent on in-class and online activities, how pertinent course modules were, technical difficulties or lack thereof, preferences for entirely online or traditional lecturing in comparison to the blended approach, and their overall opinions towards blended learning. In addition, students were prompted to provide overall comments throughout the survey that were later qualitatively analyzed and coded to uncover themes. The second assessment instrument was a comparison of students' success rates from 2010 until present for the same content taught.

In the present paper we provide a detailed overview of the course design, development, and implementation of the blended approach to instruction by communicating the technologies used, pedagogy employed to integrate online and in-class activities, and the collaboration between the instructional design support and instructor. Based on the results, we provide recommendations for engineering faculty teaching freshman courses who want to explore the blended approach to teaching. Examples for online learning activities and how to integrate them within class active learning activities to increase student engagement and success rates are included.

Key words: Engineering Freshman, Active learning, Blended course Design, & Student Perceptions.

1. Introduction

College instructors aim to craft curriculum and learning experiences which align with both the needs of the learners and the content they are teaching in order to meet expected course outcomes. College instructors are content experts who have a multifaceted role. They serve as diagnosticians who explore research-based instructional activities to address their students' learning challenges as they create assessments which evaluate how well students learn.

Continuous improvement of teaching and learning methods grounded in evidence based instructional strategies are essential to the learning process (Barr & Tagg, 1995; Cerbin, 1994; Darling-Hammond, 2008; Johnson, Johnson, & Smith, 1998). Universities realize that, in a sense, instructors serve as course designers who design learning activities to support their students learning (Wiggins & McTighe, 2005). Nationally, there has been an increase of institutional instructional design and technology support frameworks as an approach to effectively support faculty interested in exploring new teaching and course design models (Olcott Jr & Wright, 1995; Parker, 2003; Resta & Laferrière, 2007).

In the present study, a construction management faculty member and two instructional design and technology coordinators redesigned a freshman construction management course following a blended approach to teaching and learning. The course incorporated evidence-based instructional practices and a set of technology tools to enhance students' learning experiences. Student success rates pre and post blended were analyzed in addition to perspectives of freshman engineering students on the blended course design and delivery over the course of two years.

2. Background: Blended Learning

Past research shows that the adoption of blended learning courses in higher education are proving to be a means for enhancing the quality of course instruction by meeting the demands of

the 21st century learner (Garrison & Vaughan, 2008). Educators have long incorporated and combined various instructional techniques, delivery modes, and learning activities in multiple learning environments and as such, blended learning is not a new concept per se (Hobgood, 2003). However additional research also shows that blended learning courses take the rapid development of technological tools into consideration when looking at the opportunities they provide for "blending" online and face to face teaching methodologies (Hobgood, 2003; Yang, 2012). Blended learning is defined as "the thoughtful fusion of face-to-face and online learning experiences…such that the strengths of each are blended into a unique learning experience." (Garrison & Vaughan, 2008, p. 5)

Combining research on the 21st century learner with the rapid technological advancements can result in multiple benefits for students, faculty, and the institution. These benefits include flexible teaching and learning as it relates to the in class and out of class time, improved communication between instructors and students, as well as student-to-student, improved teaching and limited institutional resources (Gould, 2003; Paine, 2003; Young, 2002)

With an emphasis on the student, GonzáLez et al. (2013), found students were more satisfied with blended learning instruction in computer science and engineering courses than they were in just face-to-face instruction. Similarly, studies exploring in-part or in-whole engineering students satisfaction have shown acceptance and satisfaction with blended learning models. For example, Jones, Nee, and Chew (2008) redesigned an engineering design course by blending online tutorials with face-to-face workshop activities, field trips, and active learning in labs. They reported an positive student learning experiences with high student satisfaction rates above their university's average score. Taking it one step further, Park (2011) and Lee (2011) found students satisfaction within a blended construction management course was also higher than

traditional face-to-face instruction although their methodologies used to develop their respective blended courses taught were not necessarily similar, their goals to enhancing the quality of education through mixed pedagogical teaching practices did align.

A key outcome to growing student satisfaction through a less stringent learning model, i.e., a face-to-face classroom, is an increase in student motivation leading to an increased desire to learn. Alonso et al., (2011) found that an increase in student motivation resulted in improved learner outcomes.

In an effort to ensure a research-based approach to blended learning was followed, the development of this construction management course followed the blended learning goals created by Osguthorpe, R.T. and Graham, C.R., (2003)

- Pedagogical Richness (use class time to their advantage)
- Access to Knowledge (use more resources, connect to experts, etc.)
- Social Interaction (in class and online)
- Personal Agency (learner control)
- Cost Effectiveness (measure through freed up classrooms, increased use of TAs and adjunct)
- Ease of Revision.

In addition to reduced class seat time and to thoughtfully integrate online and in-class activities, a course clasifies as a blended course when it contains 30% to 79% of online activities (Allen, Seaman, & Garrett, 2007). The freshman undergaduate course we are discussing in the present paper was designed where 50% of the activities occur online and 50% of the activities occur in-class.

3. Course design

3.1 Course Overview. *CNST 1120, Construction Communications,* was designed to teach students how to use various construction communication tools. Students develop skills necessary for reading prints.

A set of construction documents, which include the working drawings, are the primary tool used in construction for communicating the designer's interpretation of the owner's needs to complete a project. They become the contractors' primary source for estimating, ordering material for, and constructing the project. The most basic skill for anyone involved in the construction industry is the ability to read, interpret, and analyze these documents for constructability. The outcome for the students taking CNST 1120 is to master those skills preparing them for almost all of the other construction related courses they will take in the program.

This is a mandatory course for all freshmen in the Construction Management program. Historically, the class size is comprised of 40 second semester freshman students, which is generally the entire body of incoming and transfer students.

3.2 Pre-Blended Course Structure. The pre-blended course was designed to incorporate in-class discussions and presentations combined with traditional lecturing. The course was offered twice a week. The first class session was 75 minutes followed by a 75-minute lab session. The second session of the week was also 75 minutes. The professor, who taught this class for the past seven years, used much of the class time to discuss the information covered in the text. The lab session was used to spend time working directly with the construction documents. While the professor preferred facilitating discussions in his classes, the students during the first four years came to class ill equipped to engage in meaningful discussion. Most of the class time was spent

reviewing the material they were required to read, but didn't. Quizzes were given at the beginning of the first class of each week to encourage students to come to class prepared, but in most cases, students did poorly on these. The quizzes confirmed what the students did not know, as opposed to assessing what they did. None of the class was offered online, and Blackboard was used merely as a communication tool, a place to record grades, and a repository for documents.

3.3 Instructional Challenges. The pre-blended course structure presented the instructor and students with a set of instructional and learning challenges that can be categorized into two main themes; student engagement and application of concepts.

The instructor sought to create interactive student-led dialogs in the classroom following structured discussion exercises. These discussions would serve as a tool to synthesize weekly content, identify content areas where students might be struggling, give prompt feedback, and to develop reciprocity and cooperation among the students. In order for students to successfully engage in discussions with their peers and their instructor in-class, it was essential they read material from the assigned textbook, which they often didn't do. As a result, the discussions tended to be less organized and did not cover in-depth content. Students' ill preparation became a common theme despite the course having a required textbook which aligned with the weekly lecture, quizzes, and other learning activities.

Students' ill preparation affected engagement with their peers and made the in-class discussions less effective. Consequently, the instructor would spend more class time on traditional lecturing and less time on the application of concepts and active learning activities in the classroom. There were always a great number of videos available on construction related topics, which were important for the students to see. Unfortunately, these absorbed a great deal

of class time, which could have better been used engaging the students in kinesthetic activities related directly to interpreting working documents. And at 7:30 in the morning, showing videos in class became a great time for the students to nod off.

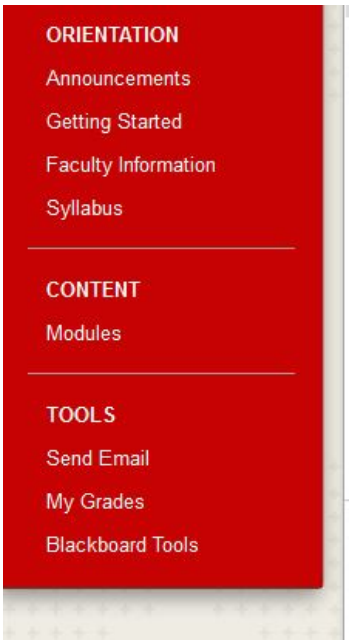
4. Methods

4.1 Course redesign Procedures. To address these challenges, the instructor, with the support of the instructional design technology team (IDTT) at the college of engineering, redesigned the course following a blended approach to teaching and learning. Over the course of a semester, the IDTT and the instructor met weekly to develop the course following the new design. The IDTT suggested a strategy which included elements of course design, organizational recommendations based on the literature, a plan to address instructional challenges, and a set of technology tools which would support the plan with the instructor's approval.

4.2 Post-Blended Course Structure. The result of the redesign was a blended course with thoughtful integration of online asynchronous and face-to-face active learning experiences. The learning management system Blackboard was used to host content and organize the delivery of material. This section describes the course navigation, in-class active learning activities, and online assignments.

4.2.a Learning Management System Course navigation: The course navigation was divided into three main areas: Orientation, Content, and Tools as demonstrated in Figure 2.

Figure 1. Course left-pane navigation:



Under the *orientation* section students had access to a) “Announcements” link containing weekly announcements sent out by the instructor; b) “Syllabus”; c) “Faculty information” with the instructors’ contact information, communication policies, and office hours; and d) a “Getting Started” area that contained technical and software information necessary for assignment completion, a Blackboard student guide, directions for the first week of class, and an explanation of the blended model as follows:

"*CNST 1121 is a 3-credit course blended course. The class sessions are scheduled twice a week; Monday and Wednesday. Starting on the 2nd week, you will not physically attend the Monday class session. However, you should not schedule anything during class time as team activities might be scheduled and you and your team members might select to meet in that time slot. On Wednesdays you need to be present in person.*

Participating in a blended course means that there are online activities that you must complete before coming to class. 50% of the course will be delivered online using the learning management system (LMS) Blackboard. As such you do not need to attend class on Monday.

These online activities are heavily integrated with the remaining 50% of the course, which will be delivered face-to-face on Wednesdays.

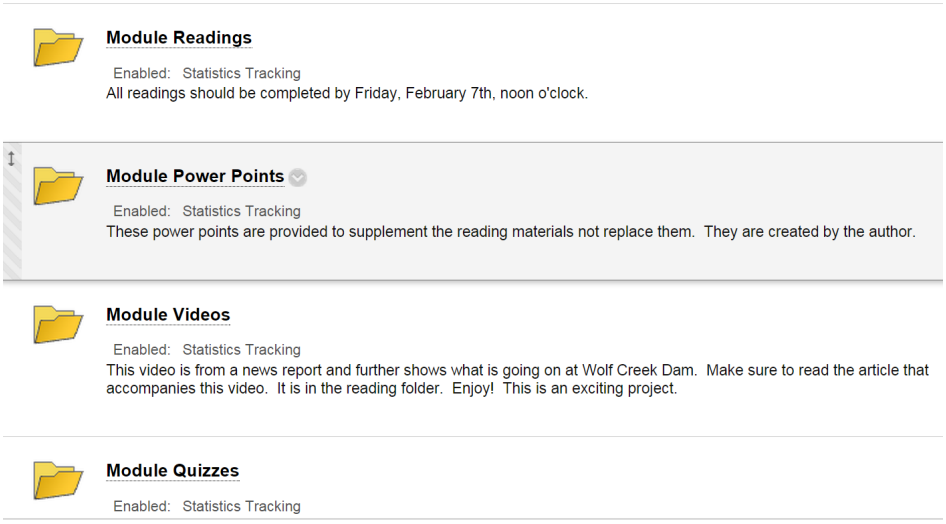
The work you do on online is essential to your success and ability to complete activities on Wednesdays. You need to complete all activities, readings, quizzes, and watch all available lectures or videos in order to be ready for your face-to-face class and lab on Wednesday."

The *Content* area contained a modules folder. A weekly module design was used. Fifteen module folders were created, one for each week of the course. The "*tools"* area contained email and other Blackboard tool information.

4.2.b Pre-class online activities: The first class period of the course was scheduled for 75 minutes. However, instead of attending the class in-person students were given the class period day off. In-class traditional lecturing was substituted with a set of online activities to be completed before the second class period (75-minutes in class followed by a 75-minute lab section).

The online activities students needed to complete were a combination of online video lectures, presentations, readings from the required text book and a set of external reading resources that the instructor provided followed by a 10 item weekly quiz. All assignments were to be completed before the physical session (which was taught on Monday mornings at 7:30 a.m.) and took an average of 4 hours to complete. The online assessments allowed the instructor to identify areas where students were struggling and use that information to modify the in-class activities. For example, if the students struggled with their understanding of the topic of floor plans based on their performance on the weekly quiz, then an extra activity or detailed discussion might be included in the following physical class period. Alternatively, the instructor would allot more time for the related in-class activities.

Figure 2. Example of weekly Blackboard online activities



4.2.c In-class activities (physical class period): The in-class activities aligned with the content provided in the online portion of the course. In fact, students' success in the active learning activities was contingent upon their preparation in the online modules. With the lecture occurring online pre-class, a variety of collaborative and engaging learning activities were introduced in the course. Students would engage in discussion on the video material provided online. They would analyze in detail examples provided them in the online videos. In addition, there was time for live student presentation and group discussions with a Q & A on the presentations. Groups would meet not only on their own out of class to complete a course assignment, but additionally in-class to apply the concepts they learned in the online modules. For example, groups would spend time on plan reading exercises and the instructor was able to spend time providing feedback to each group.

4.3 Data gathering and analysis. Data was gathered through a reflective journal kept by the instructor and a survey administered quarter into the semester and towards the end (Appendix A).

4.3.a Instructor notes: Given the new approach to teaching the instructor kept weekly notes about the course in relation to the course design, student engagement, time commitments, and areas of improvement. Instructor notes were qualitatively analyzed and coded to identify common themes.

4.3.b Student perception survey: A survey aimed at understanding the freshman student attitude towards the blended design was administrated twice during the semester (Appendix A.). The survey asked quantitative questions related to time spent out of class on assigned learning activities, pertinence of activities assigned, technical difficulties, preference towards fully online or in-person courses in comparison to the blended approach, in-class activities and qualitatively asked students to provide any additional comments or suggestions on the course design, instructor, or learning activities. The survey offered at the beginning of the semester asked students questions in a way to discover their expectations towards blended learning. The survey at the end of the semester asked the same questions, but in a way the students could express their opinions of the actual experience with blended learning.

5. Results

Several positive outcomes resulted from this course redesign. This section presents a comparison of the student completion rate since 2010, instructor perceptions, and student attitudes.

5.1 Student completion rate. The content, instructor, assessments, and activities were equivalent throughout the last five years of the course, the course design and delivery were modified. Pre-blended student failure rates were 37% in 2010, 32% in 2011, 50% in 2012, 27% in 2013. Post blending only 5 out of 37 (13%) in 2014 failed and 3 out of 38 (8%) in 2015 students failed the class all of which were due to an overwhelming number of absences.

5.2 Instructor perspective. The instructor taught the same course for 4 years. He felt the blended course was much more engaging to teach and more beneficial to the students. He believes the course redesign process was effective. Students were more prepared to interact with each other during course discussions since minimal time was spent on "traditional lecturing" in the classroom. Students were better prepared for the class discussions and had a higher completion rate on assignments in comparison to previous years. Given the amount of time students interacted before the in-person class period, he had more time to focus on interactive activities that were more complex in nature, which included analysis and evaluation.

5.3 Student attitudes. Qualitative data analysis revealed positive overall perceptions of the blended approach from the survey that was administrated twice in the semester. Two main themes emerged from the analysis:

5.3.a Students became more engaged as the semester progressed. Students noted that the beginning of the semester was a struggle. However, as the semester progressed and they were more prepared for the in-class activities, they were more engaged. About 65% of the students commented on their engagement. For example:

"*I really liked how we were more involved towards the end of the semester. Actually doing the work and finding the answers in class was more helpful to me than just listening to lectures. Blended learning was convenient because of conflicts with some other classes, I would definitely prefer it to overall online learning.*"

Another example was: "*This class is a crucial class for the construction industry and I have truly learned a lot. At the start of the semester I was a little hesitant about the quality of the class until we started to work problems out in class and learning from others. I would not change a thing about the class. The mix of online and in class is perfect and challenges you to tech yourself to truly learn the material.*"

5.3.b Students recognized that they needed to take responsibility for their learning, especially in the online portion of the course. Students commented that although the blended design was new to them, they enjoyed the experience and quickly understood the importance of engaging with the online activities and coming to class prepared. For example:

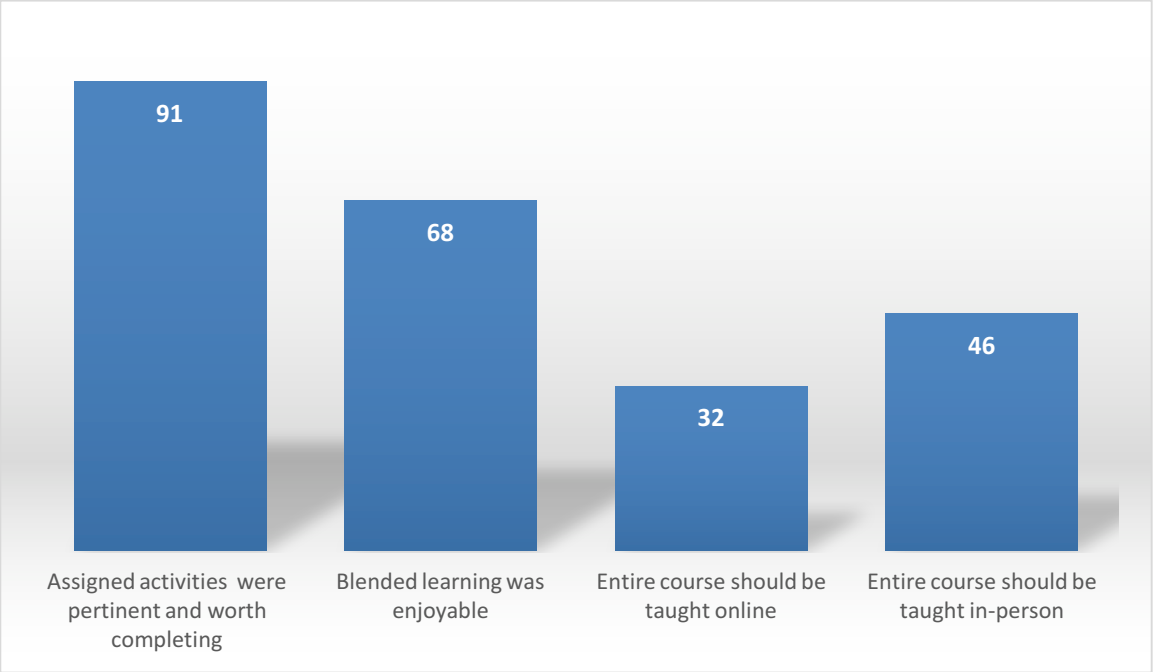
"*Being that it's my second time taking this class, I feel like having to do online quizzes and online work is more beneficial to the learning process. We actually have to read the book and understand each unit to be able to answer the questions on the quizzes. When we had quizzes in class in the mornings it was more of a quick study session before class started so I didn't really retain anything. Taking this course again in a new way is a better learning experience for me. I like the blended learning."*

Another example was: "*I really enjoyed the new blended learning technique. I hope that the college starts to use this throughout the rest of my courses. The mix of online and in class is perfect and challenges you to teach yourself to truly learn the material."*

A total of n= 91 students participated in the study. Results of the quantitative analysis of the first quarter survey were as follows, 91% (n=68) of students stated the assigned activities were pertinent and worth completing, 68% (n=58) of students stated the blended approach to

learning was enjoyable, only 32% (n=27) of students believed that the entire course should be taught online and 46% (n=35) of students thought that the entire course should be taught traditionally. Figure 4 below summarizes the results.

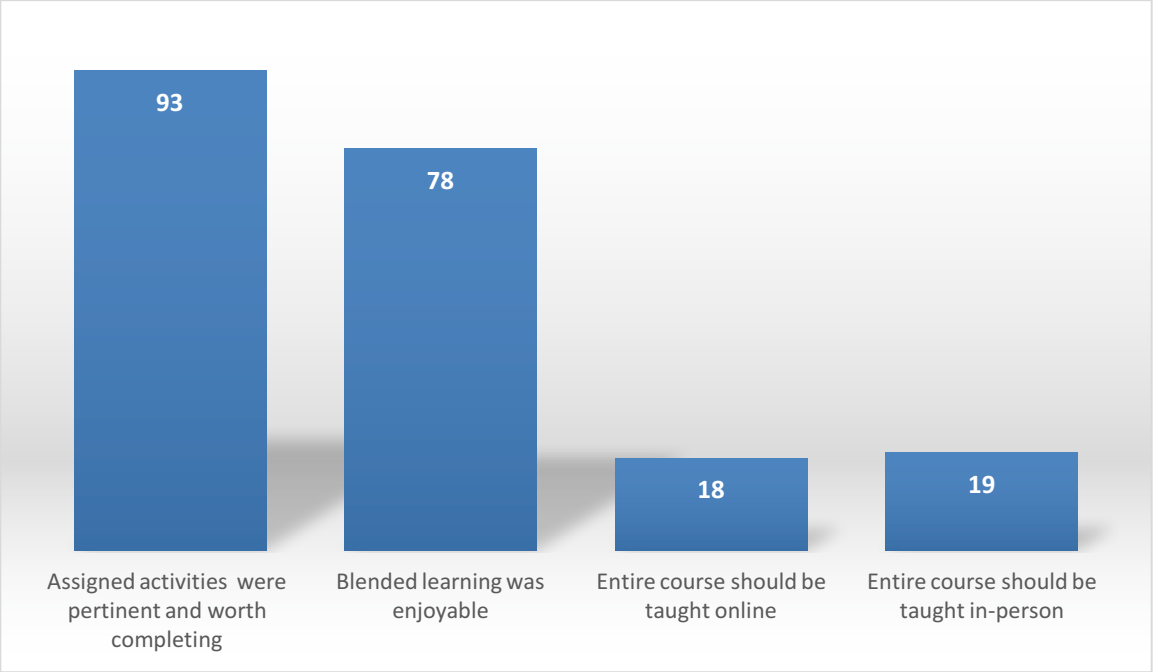
Figure 3. Two-year average percentage of first quarter survey results.



Results of the quantitative analysis of the end quarter survey were as follows, 93% (n=70) of students stated the assigned activities were pertinent and worth completing. A 2% increase over the first survey. This indicates that students' opinions towards the online and in-class active learning activities did change over the course of the semester. A total of 78% (n= 59) of students stated the blended approach to learning was enjoyable. This was a 10% increase over the course of the semester and possibly indicates that students were overall more comfortable with the new blended approach and were better at self-regulating their learning. Only 18% (n=13) of students believed that the entire course should be taught online. This was a 14%

decrease over the course of the semester. It is possible that the students began to appreciate the in-class activities. Finally, only 19% (*n=14*) of students thought that the entire course should be taught traditionally, a 27% decrease over the course of the semester. Figure 4 below summarizes the results.

Figure 4. Two-year average percentage of end of semester survey results.



5.4 Recommendations for faculty new to blended learning. We encourage engineering faculty teaching freshman level courses to re-design their courses using a blended approach. The results of this study clearly indicate an increase in students' engagement with themselves, course materials, and the instructor. Based on this 2-year experiment, the IDTT and the instructor provide the following 10 guidelines and recommendations to faculty interested in exploring the blended model in their classrooms.

1. Expect a slow start of the semester. In the blended approach students are required to self-regulate their learning and take more responsibility than typically found in a traditional classroom based on lecturing. It is typical to experience a decline the first 2 – 3 weeks in overall quiz scores. It takes that long for some students to get organized and spend sufficient time on the online modules.
2. It is essential to connect online and in-class activities. They need to be integrated in such a way that students who do not spend sufficient time on the online activities will not be able to fully experience and engage with the in-class activities.
3. End the online activities with an assessment designed to evaluate students learning of the content. These assessments should have an enough weight ratio from the total course grade so that the students put in the effort needed in preparing for the following in-class session. In this course, the online quizzes are worth 15% of the total grade. Not only will the assessments provide the students – and the instructor- with information on how well they understand the content, but also provides the instructor with an opportunity to review the results before the physical class period and adjust activities or instruction as needed.
4. State clear and assessable learning outcomes for each week. Students need to know what they should be focusing on while studying.
5. Provide students with a study strategy to assist them in learning online and on their own. This is especially important for freshman students that may have not participated in blended course in the past.
6. Provide students with a clear description of the meaning of the blended courses including the expectations. Some students might think of the first class period as a

"day off", when in fact the online activities should be substantial and require students adequate time to complete.

7. Carefully select the in-class activities. Classroom assessment techniques should rely on the knowledge students get from the online activities but be mindful of the content presented. In this course students spent time analyzing blue prints that required higher order thinking skills.
8. Similar to any new adaptation of innovative instructional methods, the course will need to be continuously refined until an effective set of online and in-class activities are selected. One strategy is to keep a reflective teaching journal. Spend 20 minutes after each class period reflecting on the learning experience of your students, both online and in-class for future improvement.
9. Survey your students more than once a semester. Your students 'attitudes might change over the course of the semester. We recommend that you gather your students' perception at least twice a semester.
10. Work with your instructional design and technology support personnel and establish weekly or bi-weekly meetings to go over your experience. They can assist with the design of the course and selection of learning activities.

5. Future Studies and Limitations

The present study had a set of limitations due to the design of the study. We list the limitations in addition to a set of future studies that may address them.

1. We recommend a set of future studies on perceptions of students in other engineering fields, the current study specifically addresses freshman enrolled in construction management and engineering fields.

2. The present study addressed only pass and fail ratios with the focus of the study on the student perception. Future studies could address students' achievement and performance in freshman courses following a blended approach.

7. **Conclusions**

In conclusion, the blended approach was widely accepted by undergraduate construction management students. Towards the end of the semester, students found the blended approach more desirable than the traditional approach. The instructor and instructional design team would recommend faculty teaching courses with design, group work, and analysis elements to apply the blended approach following the aforementioned recommendations. Students preferred the blended approach to traditional lecturing and to fully online courses.

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Appendix A. Student attitudinal survey.

Q1. How much time are spending outside of class per week on this class?

More than 10 hours per week. 7 to 9 hours per week. 4 to 6 hours per week. 3 to 5 hours per week, Less than 3 hours per week

Q2. I feel I am spending too much time for a three-credit course in completing the assignments each week.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q3. I believe that most of the activities assigned in each module are pertinent and worth completing?

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q.4 I believe many of the activities assigned in each module are just busy work and are not helping me better understand the construction industry.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q.5 By the end of the semester I was still having technical difficulties completing the activities each week.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q.6 I like the way this course is designed as it relates to Blended Learning.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q7. I would prefer doing this class entirely online and not meeting in class at all.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q8. I would prefer taking this class completely in person and not doing any of it online.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q.9 Which of the following is your favorite aspect of this class?

The book. The in class discussions. Not having class on Wednesday. The professor. The subject matter. Being able to work online on my own time.

Q.10 Which of the following is your least favorite aspect of this class?

The 5 minute presentations. Working online by myself. Not coming to class on Wednesday. Having to keep a notebook. The in class-discussions. The professor. The subject matter. The book.

Q11. I prefer having the professor include me in the class discussions instead of lecturing to me.

Strongly Agree. Agree. Neither Agree or Disagree. Strongly Disagree

Q12. If you have any additional comments or suggestions, please feel free to provide them here. Your thoughts, suggestions, and opinions are very important to me and will help me to improve the way I teach this and other classes in the future.