Development and Delivery of a Project-Based Introductory Engineering Course for Online Delivery

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Introduction

Engineering education is increasingly moving to nontraditional delivery modes, especially online delivery. Over 5.6 million students in the United States took at least one online course in the fall 2009 term.[1] This represents a 21 percent growth rate while there was only a 2 percent growth rate for higher education student population.[1] With this movement comes the challenge to meet the quality offered by traditional face-to-face instruction. In the online environment, it is often difficult to present complex engineering concepts. Also, the logistics of implementing team design projects into an online course is very complicated. An introductory engineering course typically addresses both complex engineering topics as well as team-based design projects. This paper reports on the development of an introductory engineering course for online delivery that includes team-based design projects.

Some previous work has been done with regards to moving engineering courses to the online environment. Enriquez developed an introductory circuits course for synchronous online delivery.[2] He found no statistical difference in the performance of the online students as compared to face-to-face students. Orabi showed no significant difference in the performance between online and traditional students in an entry-level engineering course, but the online students found it easier to fall behind in the content.[3] Kamp et al. evaluated e-learning in engineering education and concluded that online graphic visualizations were useful, distance-based student teamwork posed challenges, and instructors spent extra time in order to be successful in the virtual environment.[4] Brodie found that problem-based learning using online environments could be very successful and even enhance the flexibility in learning.[5]

This paper begins with some background as to why the course was developed for the online environment for the UW Colleges and the challenges that come with the online delivery mode. The process used to develop the course is then outlined. Then the course content and delivery methods used are detailed. The results from the assessment of the course are then given. Finally, some conclusions and future work are discussed.

Background

The University of Wisconsin Colleges (~~UWC~~)UW Colleges) -is part of the University of Wisconsin System. The -UW Colleges are composed of two-year campuses geographically dispersed across the state of Wisconsin. The UW Colleges mission is to prepare students for success at the baccalaureate level of education. The UW Colleges is designed to offer the first two years of a liberal arts education as well as prepare students for transfer into their selected baccalaureate program. One of the explicit goals of UW Colleges is to participate in collaborative relationships with other University of Wisconsin institutions. This goal has come to fruition by the participation of the UW Colleges with the University of Wisconsin – Platteville

(UWP) and their Collaborative Engineering Degree program. The Collaborative Engineering Degree program is designed so that students can earn a bachelor's degree in engineering from UW Platteville without ever leaving their local UW Colleges campus or home.

The University of Wisconsin Colleges has been offering the first two years of general engineering courses for over 30 years. The curriculum is offered via face-to-face instruction at five of the campuses and via Distance Education at the other campuses. Prior to 2007, the courses that were offered via Distance Education were classified as Non-Online Distance Education (NODE). The NODE delivery method is a synchronous class meeting that was either offered via audiographics or via Compressed Video. Audiographics utilizes Microsoft Live Meeting where the participants are connected via a telephone conferencing system and share a computer screen. The faculty member controls the computer and the meeting. The second method of NODE instruction is Compressed Video. Compressed Video is a teleconferencing system where the faculty member can connect via video to five remote campuses. Both methods require students to attend class at a specified time and day. The students must be physically present at their campus to attend the course. The student could possibly attend the class meeting via a different location, but the cost is prohibitive for this method of delivery, so the students are required to be at one of the UW Colleges campuses.

In response to the UW Platteville Collaborative Engineering Program, the UW Colleges faculty determined that the students entering into this program would be better served by offering the UW Colleges engineering courses in an asynchronous format. The target audience of this program is working individuals who will be able to attend courses that are not offered during the typical working day. This was not the audience that was currently being served by the UW Colleges NODE course delivery. The NODE courses must be scheduled during a normal school day as the teleconferencing system has operators only during normal business hours. In response to this, the UW Colleges faculty determined that the current course offerings would need to be developed for an asynchronous delivery mode. The faculty determined that the courses would be developed and offered in an online environment. The faculty chose the online environment because:

- The UW Colleges has a robust instructional design staff that will help faculty design their courses for online delivery.
- The online delivery would allow working students to perform their course work in a time frame that is most compatible with their schedules.
- The online delivery would allow the UW Colleges to accept students from other universities and institutions across the country. Any person can take an online course from UW Colleges by enrolling as a special student.

Over the last four years the engineering faculty have migrated all of the courses offered to the online environment. The last two courses to move to this mode of delivery are Engineering Fundamentals and Strength of Materials. This paper discusses the online development and delivery of the Engineering Fundamentals course for online delivery.

In 2005, the UW Colleges faculty of met and decided that the students were not being well served by a 1 credit – Introduction to Engineering course. The faculty felt the students were not leaving the course with the skill set required of an engineering student, specifically the ability to work well in teams, the ability to efficiently and effectively solve engineering problems (including problem identification as well as proper problem solving techniques), an overall understanding of how a practicing engineer will use technology in their work, as well as a fundamental understanding and use of a spreadsheet program. This was further evidenced by the fact that the faculty felt that students were not performing to their expectations in subsequent classes to the level that the faculty felt a freshman/sophomore engineering student should. The faculty met for two days in 2007 and determined the new course would be titled Engineering Fundamentals (EGR 105). It would be a 3-credit course where 1/3 of the course would be devoted to an introduction to computer science and computer applications, specifically spreadsheets. The course description is as follows:

> This course is designed to equip engineering students with the necessary tools and background information to prepare them to be successful engineering students as well as a successful practicing engineer. Topics covered in this course include project management, team work, technical writing, working with data and using spreadsheets, creating presentations, engineering design, and a thorough understanding of the engineering profession.

The EGR 105 course was offered in the fall of 2007 via compressed video and has been offered every semester hence. The EGR 105 course was offered in the online format in the spring semester of 2011. This paper discusses the development and delivery of the course in the online and asynchronous environment. The engineering faculty felt that since the course was originally designed by a team, it would be a natural fit for the online development to occur using a team approach. Each faculty member in the team had different educational and working backgrounds. The team was comprised of three engineers and a computer scientist. The lead designer was the faculty member that would first deliver the course in the online environment. All team members were given access to the online course so that they could access the developed course lecture notes, homework, projects, and other developed material.

Challenges

Moving a course to the online/asynchronous environment is challenging for the faculty member regardless of the course. The time requirement for developing a well thought out and media rich online course is much higher than a traditional face to face lecture. The development team determined several challenges that exist from delivering EGR 105 in the online/asynchronous environment. These are mainly due to the students being geographically dispersed. As with many engineering courses, especially project-based introductory courses, team work is vital to the success of the students. With students located all over the state, and potentially all over the world, team work becomes very challenging.

Another integral part of the traditional introductory engineering course is the inclusion of the perspective of outside practicing engineers. This usually takes the form of either a field trip to the practicing engineer's company or bringing the engineer to class as a visiting lecturer. For reasons stated above, this becomes a challenge in the online environment.

Being able to give oral presentations is an important aspect of any engineer's career. For this reason, it is emphasized in the traditional introductory engineering course. Given that students are geographically dispersed and courses are generally delivered asynchronously in the online environment, including an oral presentation into the online delivery of the course is a major challenge.

There are several other difficulties that occur with any course being moved to an online environment. Some of these challenges include the students adequately grasping new concepts, the inability to ask questions in real-time, the assessment of student understanding that comes from being able to see their body language, the logistics of the technology working as intended, and many other issues. Above are some of the challenges unique to this course. These challenges were all addressed and met to the satisfaction of the faculty. Details of how the challenges were met are in the course content section below.

Course Development for Online Delivery

The development of the course for online delivery took over eight months and can be broken into three stages: identifying the course components, designing the delivery method for each component, and developing the course content. These three stages are discussed below.

Stage 1: Course Component Identification

Due to the mission of the UW Colleges and that over 50% of engineering students receive their education from NODE instruction it is imperative that faculty and instructional staff work together to ensure the content of the courses is the same regardless of the campus or the delivery mode. The students must come into thoses classes with the same basic understanding of concepts and theories.

In the spring of 2010, the engineering faculty and instructional staff met for over five hours to discuss the course components of EGR 105. The timing was deemed appropriate as the course had now been offered for three years and a curriculum revision may be warranted. There were six faculty and instructors in attendance at the meeting. The course description and curricular outline was provided to each person. A spreadsheet was then created where each attending member listed the lessons used to cover the course topics. The lessons used to address the course topics were varied as the backgrounds of each member are highly varied. At the conclusion of the listing there were over 60 lessons/methods listed for the course. The 60 lessons were then categorized into one of three areas: computers/applications; engineering principles; team/project design. Within each category the attending faculty ranked the lessons in order of importance. At the conclusion of this exercise, the topics were then scored and a rank order listing of lessons/methods was created. These lessons/methods were identified as the course components. These components should be covered in the course regardless of the mode of delivery. The components were discussed and at the conclusion approximately 1/3 of the course content was given to each category. The members discussed the various lessons and methodologies used in class to cover the components and developed a topical outline for every day of the course. This resulted in a course shell. The attending members agreed on the shell and all agreed to be a party to the development of the online course.

Stage 2: Lecture Design and Delivery Strategies

Approximately six weeks after the initial meeting, a meeting was held by the faculty who were still interested in the online development. The pool now dropped to four faculty members. The members met for a single eight hour meeting to further discuss the course.

The initial portion of the meeting was to create the course schedule, therefore identifying the order of the lectures. The course would be comprised of 45 lectures. A master schedule was created for the development. Each lesson was placed into the schedule, and the lesson was determined. The attending faculty then discussed the textbook chapter that would best support the lecture material. Each attending faculty member used a different book, therefore the pros and cons of each text were discussed. At the conclusion, a chapter from a book was identified. The faculty initially used texts from all publishers, but quickly determined that we would need to stay within the confines of a single publisher so a custom book could be easily created. The team decided to use Mc-Graw Hill. Along with the text identification, a team member was designated to be the developer of the content for the lecture. This team approach to development allowed each member to work in the area where they felt they had expertise. This approach worked well. The team tried to split the work evenly, but the lead instructor created approximately 40% of the lectures. The computer scientist created about 30% and the remaining lecture were split among the remaining team members.

Stage 3: Developing Course Content

The lead instructor supplied each team member with a lesson template so that the format of each lesson was the same to provide some continuity in the deliverables of the course regardless of the person developing the lecture. Each team member then began developing their lectures. Each member worked with the lead instructor and the online instructional designer to create the lecture material for the course. The lead instructor also worked with Mc-Graw Hill and created a custom textbook for the course based upon the chapters the team selected that best tied to the lectures. The team used some innovative approaches to lectures and project team work. These methods were discussed at the second team meeting. The approaches and methods used to deliver the course content are in the Course Content section of this paper.

Course Content

The EGR 105 course is comprised of 15 units which coincide with a 15-week semester schedule. The team felt it would be easier for the students to work in units that aligned with a calendar; therefore the 15 unit schedule was completed. As discussed previously there were three categories identified for the course: computers/applications; engineering principles; team/project design. The team determined that each unit would be comprised of 3 lessons equating to the three categories of the course. Two lessons each unit were devoted to engineering principles and team/project design and one lesson was devoted to computer science/applications.

The result of this development was the creation of 45 student lessons. Each lesson was comprised of lecture notes and videos, reading assignment, and homework. The lecture notes were developed by a team member, the reading assignment was from the custom Mc-Graw Hill textbook, and the homework was either from the textbook or created by the team member

creating the lesson. The team felt that this information covered a majority of the material that would be delivered in a face-to-face class. The team did feel that the student taking this course in the online environment would be missing certain course components that face-to-face students would receive, specifically those topics addressed in the challenges portion of the paper. The following sections illustrate how the team addressed each of the challenges presented earlier.

Team/Project Design Work

The team felt that the students in the EGR 105 course regardless of mode of delivery would be required to complete two team project design projects. During the second team meeting the various projects employed by the team members were discussed and two projects were selected for development. The projects are somewhat scaled back as compared to projects typically done at a baccalaureate campus due to the lack of equipment and the geographical dispersion of our students.

The first project is the Mouse Trap Car project. This is a typical high school physics project, but the team has used this project before with great success in this course. The project is to design a mousetrap car where teams design a single car, create specifications, engineering sketches and assembly directions. From their technical documents, each student built a car and tested it. The results were compared and analyzed to identify missing information in the specifications and/or assembly instructions. The documents were then revised to ensure a more repeatable design. A final car was built and mailed along with the specifications to the instructor for final assessment and testing. Upon receipt of all cars, the cars were tested by the instructor and the winner declared. A portion of the final project score was based on how well each car did. The entire testing was videotaped. The instructor edited the tape and posted a condensed version of the test was posted on YouTube for the students to watch.

The second project was the Wind Farm project. The project was to design a wind farm to meet the electrical needs of a campus. Students were given hourly wind data for a year as well as electricity usage data for a campus. Students analyzed the data and researched specific windmills on the market in order to design a wind farm for campus. The deliverables for this project were a written progress report as well as a final written and oral proposal. For the completion of these projects the students were randomly placed into teams of four.

Once the projects were selected, the next hurdle was to determine how the students would communicate efficiently with each other so that they could complete their projects. The course used multiple methods of communication including email, virtual office hours, and discussion boards. The students could also use their own social networking systems as well as their mobile phones. The UW Colleges uses the Desire2Learn course management system to deliver online courses. The EGR 105 online course employed the use of discussion boards. There were discussion boards that were used by the entire class, and there were boards that were used for the team to hold private conversations. The threaded discussion was maintained throughout the semester.

Another method of communication was the use of a virtual classroom. The UW Colleges uses the synchronous meeting tool “Elluminate”, by Blackboard. This meeting room allows for VOIP communication, the use of Whiteboards, application sharing and web tours as well as break out

rooms for private discussion. The lead instructor felt that this was such a vital tool for the EGR 105 students that there were two mandatory virtual meetings during the first week of the semester. The student could attend either one of these meetings. The main purpose of the meeting was to introduce the students to Elluminate and explain how to use all of the conferencing tools. After the completion of the mandatory meeting, each team was given their own individual team meeting room where they would be the only participants in the room and they could meet with their team members. Due to the anticipated heavy use of the virtual classroom the purchase of headset/microphone was a requirement for this course.

To help further the students' understanding of an engineering design project, the lead instructor acted as the project manager for the first project. The students had weekly milestones for their project that were addressed in their weekly assignment. For the second project, the students would elect a project manager and they submitted a single progress report half way through the second project.

Oral Presentations

The final component of the wind farm project was to have a final presentation of their design proposal. The faculty determined that the teams would present their final project to the entire class. The faculty felt strongly that this presentation needed to be made to the entire class so a synchronous meeting was created as part of the course. The final project presentations were held in the virtual classroom the last day of classes for two hours. This was a mandatory meeting and the students were informed of this meeting prior to the beginning of the class.

Engineering Professionals

As stated earlier, one of the components of a face-to-face EGR 105 course is the interaction with a practicing engineer. Either the engineer would visit the class or the students may visit the engineer at his/her job. The faculty felt this was a vital experience for any EGR 105 student regardless of the mode of delivery of the course. In response to this the faculty determined that practicing engineers would be interviewed and recorded. These recordings would then be made available to the students. As stated previously, the course is comprised of 15 units and each unit has a theme. The lead instructor developed a set of questions that corresponded to the theme and the lessons that were created for the unit. Two engineers were identified (a civil and a mechanical engineer) each with over 20 years of working experience to be our interviewees. A camera crew was sent from the instructional designer and interviews were conducted. The recorded interviews were part of the course and attached to each unit.

The interviews were held at different locales, but were edited into one single recording for the students. This delivery of the interviews is more robust than anything that could be delivered in a face-to-face course as the engineers discuss how he addresses the topic in each unit. The faculty felt this was an excellent addition to the course and was well worth the time and expense of creating the videos.

Connecting with Students

The challenge with any online class is the ability of the professor to connect with his/her students to ensure the understanding of key concepts by the students. The students do not have the ability

to drop by the faculty member's office and obtain help with homework, or just to sit and check in on how their semester is going. The lead instructor employed the use of virtual office hours and the use of the Elluminate classroom. The lead instructor has over 4 semesters of experience with the virtual classroom and has found great success in connecting with her students.

The use of the virtual classroom, online office hours and the practicing engineer interviews were all used to help meet the challenges of offering the EGR 105 course in an online environment. The faculty felt that these methodologies would help the students receive an educational experience similar to the experience they would receive in a face-to-face delivery mode.

Assessment

When EGR 105 was delivered for the first time, assessments were conducted to compare the online course to the traditional face-to-face delivery mode. The semester the online course was first offered, it was also offered in its traditional format by one of the team of developers. This provided a direct comparison between the two delivery modes for the course. The course content was nearly identical between the two modes. All the homework and projects were the same in each section. Each section also followed the same weekly schedule so the concepts would follow the same order. Of course, small changes were made in order for the content developed for online instruction to effectively fit into a delivery format of 75 minutes, twice a week.

The goal of the team was to ensure that the students in the online section had the same experience and success as the students in the traditional face to face section. Several assessments were used to determine if the online students attained the same experience and success as the students in the traditional face to face section. One assessment was a quantitative analysis comparing the grades of each section. Also, two surveys were created for the students to take and reflect on their work on the projects and the course. The first survey was given after the first design project and focused on how the course structure aided in teamwork on the project. The second survey was conducted at the end of the course focused on both the final project as well as the course as a whole. The fourth assessment was an analysis of the viewings of the engineering interviews for each section. Finally, the two instructors for each section met and discussed their perceptions of the course, the projects, the students and the overall experience of the course at the conclusion of the course.

Student Grades

The first assessment tool used to compare the two sections was student grades. Since identical assignments were given in each course section, a direct comparison of grades between the online and the face-to face section was made. While there was some subjectivity to grading, a rubric was created for each assignment and project which helped normalize the grades.

Table 1 shows the results of the grade comparisons for each section. The mean score for each assignment, project, and final exam are given. Table 1 also shows the resulting p-value from the t-test for each assignment. For this analysis, if the p-value is less than 0.01, there is a statistical significance between the sections. A noticeable result from this comparison was how much better the online students did as compared to the traditional students. The p-values for three assignments, the mousetrap car project, the take home Excel final, and the overall course grade

were less than 0.01 indicating a statistically significant difference in these grades. In each case, the online section did significantly better than the traditional section.

Assignment	Online Mean	Traditional Mean	P-value
Unit 1	95.7%	100.0%	0.13349
Unit 2	**93.8%**	**80.5%**	**0.00933**
Unit 3	88.4%	76.6%	0.13740
Unit 4	89.5%	78.4%	0.04184
Unit 5	**89.6%**	**58.7%**	**0.00578**
Unit 6	93.4%	75.7%	0.01944
Unit 7	81.4%	59.6%	0.10376
Unit 8	84.6%	64.9%	0.12049
Unit 9	92.8%	76.2%	0.02808
Unit 10	82.1%	68.5%	0.08296
Unit 11	**72.5%**	**34.7%**	**0.00342**
Unit 12	86.4%	66.2%	0.09971
Unit 13	86.5%	72.4%	0.16086
Unit 14	90.4%	57.3%	0.02722
Project 1	**95.7%**	**88.9%**	**0.00067**
Project 2 Presentation	90.6%	66.5%	0.01913
Project 2 Proposal	90.7%	67.8%	0.02644
Take Home Final	**87.8%**	**50.8%**	**0.00718**
In Class Final	84.3%	66.8%	0.03748
Total Grade	**90.9%**	**70.2%**	**0.00076**

Table 1: Grade comparison between traditional and online sections

These results are consistent with the results of a 2010 Sloan Consortium study surveying the perceptions of the quality of online instruction. In the survey over 75% of academic leaders at public institutions report that online is as good as or better than face-to face instruction.[1] The speculation for this difference may be due in part to the quality of the students in each section as opposed to the delivery. Both instructors have taught this course several times and the online instructor had one of the best groups of students she had ever had and the traditional instructor had the worst students he had had for this course. Nonetheless, with the better section being the online students, there is little concern that the content was not delivered adequately via online delivery. From Table 1 it can also be seen that the assignment from Unit 11 was relatively low as compared to the other assignments. The assignment was on unit conversions and consisted of an exceedingly large amount of conversions to be done by hand as well as using Excel. It was not that students were unable to execute unit conversions; it was that students were unable to complete all the conversions. The assignment was too long and will be shortened in the future. Overall, when comparing the grades of the two sections, the online students performed better

than the traditional students demonstrating that the online delivery was more than adequate in achieving student comprehension of the topics.

Student Survey of the Mousetrap Car Design Project

The first student survey was given after the mousetrap car project. The survey asked ten questions on a five-point Likert scale regarding the first project and how well the teams were able to work together as well as their overall impression of the project. The survey is included in the appendix. This survey was given to both the traditional face-to-face section as well as the online section and a Student's t-test was performed to compare the results between sections. Table 2 shows the results for each question on this survey including the averages and p-values from a t-test.

Question	Online Mean	Traditional Mean	P-value
1	4.56	4.38	0.5053
2	4.56	4.08	0.1226
3	4.67	4.15	0.1032
4	4.56	4.31	0.4109
5	4.56	4.62	0.7935
6	4.22	4.31	0.8087
7	4.56	4.31	0.2773
8	4.67	4.31	0.1109
9	4.11	4.23	0.6514
10	4.67	4.54	0.6104

Table 2: Results from student survey following Project 1(Mouse Trap Car Survey)

The mean score for each question is given for each section. The average score is above four for all questions in both sections. The students seemed to have a positive experience with the project including working with their teams. Table 2 shows the p-value for each question is above 0.01. Therefore, there is no statistical difference in the responses of the two sections. The online section perceived the project and working in teams similarly to the traditional section. The fact that both sections had an equally positive response to the project demonstrates the methods used in the online delivery lead to an experience equivalent to what is traditionally offered.

The qualitative data revealed similar comments in that both sections had an overall positive experience with the project. The qualitative data revealed dissimilar comments when discussing teamwork. The traditional section had comments that suggested it was difficult to find time to meet as a team, that more "in class time" should be given for the teams to work together and that the students would prefer to pick their own teams. The online section overwhelmingly had positive comments regarding the team work. The common theme in the comments were that it was easy to meet as a team, the use of Elluminate was indispensible in allowing them to work as a team, and that they felt they really got to know their teammates. The speculation of the instructors is that most of the online students had full-time jobs and had scheduled time in the evening to work on their coursework. Therefore, it is most likely that the students had an

expectation of doing work at night. The project work was most likely considered to be part of their work expectations for the course. In contrast, the traditional section students also probably worked, but worked outside of normal school hours (most likely evening and weekends) and therefore, it became difficult to meet as a team outside of traditional school time.

Student Survey of EGR 105

The second student survey was given to each section at the end of the course and considered student's reactions to both the wind power project and the course as a whole. There were 11 questions on a five-point Likert scale for this survey as well as their overall impression of the wind farm design project and the course. The survey is included in the appendix. Table 3 shows the results for each question on this survey including the averages and p-values from a t-test.

Question	Online Mean	Traditional Mean	P-value
1	3.22	3.92	0.2017
2	3.78	4.25	0.3878
3	3.78	4.25	0.3627
4	4.33	4.50	0.5927
5	4.33	3.67	0.0758
6	**4.00**	**2.67**	**0.0089**
7	4.56	4.33	0.5147
8	3.89	3.67	0.5027
9	4.44	4.08	0.2927
10	3.56	4.08	0.3350
11	4.44	4.17	0.4537

Table 3: Results from student survey following the course (Student Survey of EGR 105)

The first three questions considered the wind project as compared to the mousetrap car project. These scores were relatively low. The instructors were not clear as to why the scores were low, because overall the student comments were mostly positive. The traditional section students all stated they worked better as a team on the second project. Overall, they stated they found it easier to work as a team and get their work done. The online section had two of seven teams state they did not work well on the second project. One student commented, "I think our team worked better together on the mouse trap project because what needed to be done for the project was more clear cut." Another noted, "The team did not function well at all. The initial meeting was only attended by 3 of 4 members and the scope of the project was beyond what anyone could comprehend." The other five teams in the online section all reported similarly to the traditional section, in that the teams worked much better in the second project as compared to the first.

In addition, questions 8 and 10 having to do with pace and workload had relatively low scores. When the surveys were examined for comments, most students felt the work was appropriate and did not have a strong opinion regarding the amount of work. No one complained that the work was excessive, yet the scores do not reflect this. Based on the comments, it is the belief of the instructors that the students felt it was appropriate. The instructors felt that the amount of

grading was excessive for the course. Each week the instructors were required to grade three assignments; an engineering assignment (typically two sections), a computer assignment, and a project assignment (for the first half of the course). Finally, question 6 dealing with the textbook was not only low, but the traditional section was significantly lower than the online section with a p-value of 0.0089. There were some problems with the textbook including one section was out of order and that the chapter numbers in the text were not sequential, therefore at times making it confusing to determine where to look. These issues have been rectified in a new custom textbook. The difference between the two sections stems from a lack of buy-in from the traditional instructor who historically used no text in the course. However, aside from question 6 the p-values are all less than 0.01 indicating there is no statistical difference in the responses of the two sections. Both sections had statistically similar experiences regardless of the delivery method of the course.

Engineering Interviews

The team of developers felt that the engineering interviews were a vital component to the course. The interview topics were tied to each unit and demonstrated to the students how the week's material was applied in the "real world". It was also felt that it in some way reinforced that the topics that were being discussed and taught would be perceived as relevant to the student's future career. Much time and money was used to create the videos and both instructors felt it enhanced the course. The traditional section students were told to log onto a website outside of class to access the engineering videos prior to coming to the class each week. The online students had access to the videos along with their assigned readings and other course materials. The time spent by each class on the engineering interviews were analyzed. The analysis revealed that the videos did not work for the traditional section and were better received by the online version. Table 4 summarizes the findings.

	Percentage of Students Viewing	
Interview Number	**Traditional**	**Online**
1	20%	100%
2	27%	87%
3	27%	74%
4	13%	74%
5	7%	70%
6	0%	65%
7	7%	61%
8	20%	70%
9	7%	65%
10	13%	65%
11	20%	70%
12	0%	65%
13	7%	57%
14	0%	65%

15	7%	43%

Table 4: Results from comparison of number of students viewing interviews

The results show that there is a significant difference (p-value = 1.86647×10^{-13}) between the traditional face to face section and the online section with regards to the viewing of the interviews. This data was disconcerting to the instructors as it was the feeling that this was a vital component to the course. It was the belief of the instructors that the interviews could be viewed as the glue that tied the course to the real world. The instructors believe this is a function of the interviews themselves. The traditional section was told to view the interviews prior to class each week; however, the students may have viewed this an "optional or supplementary" activity that should be done in addition to attending the class. The videos for the online section were embedded into the course material. Therefore, when the students were reviewing the material for the unit the interview was one more component of the course and was most likely not viewed as an "optional or supplemental" component, but part of the course material.

Instructor Perceptions of the Course

The final assessment was the instructors' perception of the course. The online instructor and the traditional section instructor had very different experiences with the course. During a meeting after the end of the semester, the traditional instructor noted that the cohort of students in the class were the worst group of students he has had in the three years teaching the course. The online instructor found that this was the most motivated and engaged cohort of students that she has had in her three years of teaching the course. It is the belief of the online instructor that this is a result of the type of students who took the online course. Most of the students in the online section were non-traditional students (over the age of 22), were working full time jobs and many had families. The students for the most part were highly motivated students working on attaining an engineering degree while working full-time and maintaining many other obligations. It is the belief of the traditional section instructor that many students were taking this course to "test the waters" and had little intention in attaining an engineering degree.

Both instructors tried to offer the course material in a similar manner, the traditional course was very structured and did not allow for "extra time" to be spent on a subject if the students struggled. If the students did not understand a concept they were required to come to office hours or spend extra time after class with the instructor. The traditional instructor found it nearly impossible to cover all of the course material in the allotted class time. The online instructor did not have similar experiences because the students were responsible for the material. The lecture notes, videos, and other information were presented in a concise and easy to follow format, but it was the student's responsibility to complete all of the course work. Therefore, the online instructor never felt pressure to meet a schedule for the delivery of the course material.

Both instructors reviewed the amount of time spent on this course as compared to previous semesters. Both instructors felt that this course was more time consuming than previous offerings of the course. The traditional section instructor noted that he spent more time one on one with students and after class reviewing material as it was difficult to get through all of the course material during class time. The traditional section instructor felt constrained by the structured format of the course. Overall, the traditional section instructor felt he spent 10 hours on the course each week. The online section instructor noted that she spent more time on the

online course as compared to previous semesters. The instructor believes the online environment is an excellent mode of teaching some courses, but requires an excessive amount of time to teach it well. Much time is spent communicating with students in and out of virtual office hours, attending students meetings if requested and grading homework. The online instructor had 3 virtual office hours a week which were almost always attended by students, had over 1700 posts to the discussion boards throughout the semester, and as many emails in which to read and respond. On average the online section instructor felt she spent in excess of 20 hours per week on this single course.

The online instructor believed that the use of Elluminate for the virtual office hours and synchronous meetings was vital to the success of the students in the online section and to their working as a team and producing quality projects. The use of Elluminate aligns with Moore's theory of transactional distance. The theory states that distance is a pedagogical phenomenon and the learner is not considered with location, but with student interaction and engagement.[6] The use of Elluminate allowed the students to be connected with the professor and with their teammates.

Both projects were reviewed by both instructors at the meeting after the end of the term. The instructors felt that the quality and level of detail presented by the online student teams far exceeded the projects of the traditional section teams. The quality of the presentations was superior for the online students, and the data analysis for the wind project was at a greater level of detail for the online students. Both instructors feel this may be attributed to the ability of the online students to work more effectively in teams than the face to face students.

Both instructors believe that the interviews are a vital component to the course and allow the students to not only understand what a practicing engineer does in his or her career, but the interviews add relevancy to the course material. Both instructors were disappointed in the number of students who viewed the videos and had expected that all students would watch all of the videos.

Conclusion and Next Steps

A team of engineering faculty and instructors met to analyze an existing Engineering Fundamentals course developed, and delivered the course in an online environment. A list of learning outcomes and topics were developed and the delivery of each topic was chosen to achieve the desired learning outcomes given the constraints and possibilities of the online environment. The course was broken into 15 units, each unit was composed of 3 lessons corresponding to the three major categories of the course (computers/applications; engineering principles; team/project design). Most topics were delivered using online text and/or videos created by the team of faculty and the instructional designer. In addition to the online components, a custom textbook was built with help from a publisher for students to reference during the course. Interviews of two engineers were recorded to give students an engineer's perspective of most topics during the discussion of each topic in the course. Students were able to meet synchronously with each other or with the instructor using a virtual classroom. Two team design projects were developed for the course. An oral presentation was required for the second project and was conducted in a virtual classroom. Two synchronous meetings were required of the students.

When the course was initially taught the online section performed better the traditional face-to-face section showing the online environment was successful at delivering the course content. In addition, the perceptions of the course by students were similar for both sections. Two surveys given to students in both section had similar responses. The engineer interviews were much more utilized by the online students versus the face-to-face students. This may have been due to a perception that the videos were optional for the face-to-face students. Finally, both instructors felt the course was successful, but a little too much work for both the students and the instructor.

Moving forward, the course will be offered again after some minor revisions. These revisions include making the course ADA compliant and changing the homework. The homework will be shorter and will include questions regarding the interviews for the unit. It is the belief that this will encourage students to view the videos. The online course was successful in that the online section students had better grades as evidenced by the data analysis and had similar experiences as the traditional section students as evidenced by the results of the two surveys. The results show that project based introductory engineering course may be successfully taught in the online environment.

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