

Comparative Analysis of Online Versus Face-to-Face Delivery of Mechanical and Electrical Systems Course in a Construction Management Curriculum

Robert Soares, Ph.D., Taylor Wynn, B.S, and Syed Ahmed, Ph.D.
East Carolina University
Greenville, North Carolina

The traditional classroom university setting is being challenged by the delivery of class material through online platforms. There are varying results on the effectiveness of online courses, but multiple studies have revealed that web-based programs are just as, and in some instances more, effective than traditional classroom settings. This article focuses on a specific instance of online instruction for a construction management program. A Mechanical Electrical and Plumbing (MEP) Systems in Buildings course was offered online for students desiring to enroll in this class while on-site at internships throughout the nation. The online course was designed utilizing MediaSite Software and Blackboard, and these platforms allowed students to view lectures and classroom materials through videos posted online, and the subject matter could be observed anywhere in the world at students' convenience. The MediaSite Software provided data that allowed the instructor to observe student viewing trends; for example, graphs were provided revealing how many times in a certain day a single student accessed lecture videos. Comparing outcomes of the online delivery to the same class taught face-to-face reveals material was captured just as adequately for the online students, suggesting the online design did not negatively affect distance students' learning. Recommendations are made for expanding construction management degree programs to include more online classes for distance education students currently employed in the field.

Keywords: distance education, online courses, MediaSite Software, MEP class, online curriculum, construction management

Introduction

One of the core disciplines in an accredited Construction Management (CM) curriculum is Mechanical Electrical and Plumbing (MEP) Systems in Buildings. Personal experience has revealed that, depending on the level of comfort and sustainability required in a project, MEP systems could correspond for more than 50%, and up to 70%, of the total investment in a new building. A significant barrier to designing projects is planning spaces for MEP systems (Riley, Varadan, James, & Thomas, 2005). For this reason, it is very important that CM students acquire adequate skills to properly manage the selection, installation, and start-up of these systems, and to deliver this service with an elevated level of quality while maintaining a budget. Recently, the CM program at East Carolina University (ECU) has faced an obstacle with providing required MEP systems information to the student population.

Over the past five years, the undergraduate CM program at (ECU) has experienced a continuous increase in students. Boasting an enrollment of over 600 students, the CM program possesses one of the largest student populations among ECU programs. With this level of enrollment, there is a high demand for MEP courses, and these specific classes are offered in the Spring and Fall semesters and rather absent during Summer sessions. During the summer, most of the student population leaves the area to work at internships throughout the nation, and therefore, students

cannot enroll in MEP classes while on the job site at various locations. A solution to the issue of students attending summer MEP classes is to offer the course online.

Many universities have switched to online and hybrid platforms to keep up with growing academic needs, and multiple studies have been performed to study this trend. Researchers such as David & Sung (2009) have discovered that utilizing an online platform, as compared to a face-to-face (F2F) class, does not negatively impact a student's learning processes. One study revealed that overall, grades for students enrolled in an online platform were comparable to students that attended F2F classes (Callister & Love, 2016). This outcome was discovered with students in an electrical and computer engineering program, as well, and after considering for GPA as a covariate, delivery style of course material did not affect performance (LaMeres & Plumb, 2014). Additionally, another study concluded that after offering an Introduction to Management Information Systems course to F2F, blended, and online sections, students enrolled in the online portion reported higher scores for being "motivated to work at my highest level," and "increased my critical thinking" (David & Sung, 2009).

Learning is a flexible and dynamic process and applying it through an online strategy can be beneficial to this program (Driscoll, Jicha, Hunt, Tichavsky, & Thompson, 2012). Although learning is fluid, it is suggested that online education is designed appropriately to capture equal effectiveness as F2F lectures (Driscoll, et al. 2012). Sources suggest that professors should devote time and energy to developing an effective online platform that is easy to use and navigate (Riley, Ellegood, Soloman, & Baker, 2017). Therefore, the online MEP class was developed to encompass these characteristics by utilizing MediaSite Software and Blackboard. This analysis will focus on comparing the results of the online platform versus a F2F Mechanical Electrical and Plumbing Systems class taught by the same instructor within the same university.

Method

The course Mechanical and Electrical Systems was taught to undergraduate Construction Management students at East Carolina University. For comparative purposes, the F2F course section was taught during the Spring 2018 semester, and the online portion was completed during the Summer 2018 semester over a five-week period. 37 students enrolled in online delivery will be analyzed. Both classes were taught by the same professor and utilized consistent textbooks, materials, and lectures, both in a similar sequential order. Although the Summer course was condensed into five weeks, and the Spring course was completed through the duration of approximately 15 weeks, the two samples were equivalent in terms of contact hours. Therefore, each course received the same total amount of contact hours with the professor.

Online Course Delivery: MediaSite Software

All lessons were broadcasted and recorded using Sonic Foundry's MediaSite Software. Since research reveals webcast viewing can be associated with higher performance, a viewing platform was integrated into the MEP online curriculum (Traphagan, Kussera, & Kishi, 2010). This fully integrated software allows for video instructions and lectures to be captured and distributed live over the Internet, and the design provides significant flexibility and quality of learning for students (Vasu & Ozturk, 2008).

The online class was delivered with recorded video of the instructor performing lectures. The professor was shown teaching material through reviewing textbook contents, discussing powerpoint presentations (PPT), and showing experimentation or demonstration. This software is also compatible with Blackboard, and this allows each class to be labeled with the corresponding lesson plan and stored in a library. After classes are recorded, students can access video lectures through Blackboard and can even view, pause, rewind, and fast-forward through content.

Whenever students assess the MediaSite Software through blackboard, viewing data is recorded per day and month. This provides data for the instructor to identify viewing times, per student, spent watching the videos. Each instance the video is accessed, the software provides a set of graphs identifying the amount of viewing time spent on the material. Degrees of intensity are shown through a color key ranging from green to red, and red is the level of

highest intensity. This tool provides instructors with information on the level of activity and coverage for individual students across each class. Therefore, commitment levels of students can be extrapolated from analyzing viewing times and dedication to the subjects.

Forty hours of instruction was necessary to gain 3 credit hours; therefore, a total of 41 videos was generated, with 2,403 minutes (40.05 hours) of teaching. 772 minutes were dedicated to Electrical Systems and Fire Protection Systems, 838 minutes dedicated to Mechanical Systems, and 793 minutes allocated to Plumbing Systems and homework solutions.

Curriculum Design

Syllabus and Student Expectations

For the online class, a special direction is described in the syllabus, empowering students to "attend" classes through viewing online lectures and dedicating as many hours per week possible to study materials. The rationale of this statement is that the instructor cannot enforce attendance, and therefore, students are responsible for managing individual "class time". Students are recommended to dedicate at least two hours per day, or eight hours per week, to viewing provided video lectures. This direction is displayed in the syllabus as:

> *"This is an ONLINE course that will deliver the same contents of instruction that a traditional face-to-face class does. The contents are recorded in VIDEO that can be assessed anytime, and anywhere you are. They will cover the study of mechanical, electrical, and plumbing systems, applicable codes, and effect on the construction process. Coordination with various construction document formats and media, as described in the catalog. IT IS YOUR RESPONSIBILITY TO VIEW ALL THE VIDEOS AND DELIVERY THE HOMEWORK ASSOCIATED, ACCORDING TO THE DUE DATE OF EACH ASSIGNMENT DURING THE PERIOD OF 5 WEEKS. OBSERVE THE DUE DATES OF EACH ASSIGNMENT AND USE WISELY YOUR TIME TO LEARN ALL THE CONTENTS OF THE COURSE, DEDICATE AS MANY HOURS PER WEEK YOU CAN TO BE SUCCESSFUL IN THE COURSE."*

Student Learning Objectives (SLO)

ECU Construction Management department curriculum requires the fulfillment of six steps that include, (1) access and follow American Council for Construction Education (ACCE) Student Learning Objectives (SLO), (2) development of Class Learning Objectives (CLO) created by the curriculum committee, (3) selection of course contents to fulfill the requirements of each CLO, (4) course delivery and students' work evaluation, (5) assessment of students' evaluation, and (6) make changes to provide continuous improvement in the quality of the course. Following is the discussion of each step, in detail.

Step One: ACCE Students' Learning Objectives (SLO). The first step is to follow ACCE Students' Learning Objectives number 20, which states: "Understanding the basic principles of Mechanical, Electrical, and Plumbing options". This objective must be completed to maintain ACCE program accreditation.

Step Two: Class Learning Objectives (CLO). The second step is to answer how the ACCE SLO will be fulfilled, and the curriculum committee develops this task. After speaking with professionals in the field, the committee collaborates to develop CLO's for the MEP course. Five Class Learning Outcomes (CLO) were developed and cover the following systems: (1) Plumbing, (2) Heating and Cooling, (3) Electrical Power Productions and Transmission, (4) Power Distribution, and (5) Fire Protection, that are respectively CLO 1,2,3,4 and 5. This is displayed on the syllabus, as well.

Step Three: Course Content. Next, adequate material must be developed to relay the CLO to students, and this includes searching for textbooks and relevant teaching materials. The results of a comparative analysis of several textbooks indicate that the availability of textbooks covering all areas related to these CLOs is difficult. There are textbooks that cover specific areas in-depth but are deficient other areas required by the CLOs for the course. Using the criteria to find a textbook with total coverage for all areas, the text *Mechanical and Electrical*

Systems in Buildings, 5th Edition by Janis and Tao, Pearson Editors, was found to be the most convenient for the course. It requires a few additional materials to cover the course, and for this reason, it was adopted.

Step Four: Students' Results Analysis. The fourth step involves the result analysis of student outcomes. Students are administered 10 tests distributed among the five CLOs. Each test contains an average of 50 questions, is submitted through Blackboard, and students are provided a designated window of time to complete the test. In order to compare with the criterion for success, the data set of student answers is tabulated according to the percentage of right versus wrong answers. For this course, the criterion for success is, "75% of students will receive 75% or above on tests," and this determines whether the goal was met or not. If the goal was not met, the instructor must identify areas of weakness and make corrective actions to improve course quality. If the goal is met, this is an indication that the instructor can increase the level of challenge and overall course quality.

Steps Five and Six: Analytical Measurement. Finally, analytical measurements of students' work are composed in preparation of an assessment report for each SLO. The following format is used for these reports: 1- Actions taken: Instructor describes all teaching activities made during the course to fulfill requirements of the specific CLO. 2- Results: Instructor indicates results of the criterion for success using the percentage of students that meet/not meet the goal. 3- Analysis of the results: Instructor reveals justification of results for the specific CLO. 4- Actions planned for next Reporting Semester: Instructor describes proposed actions to improve course quality.

Student Assessment

Student assessment will be formulated based on each CLO. In this section, each CLO is defined, and viewing information and assessment is provided for individuals CLO's.

Course Learning Objective 1. Describe and compare materials, fixtures, fittings, and appliances for plumbing supply. 11 videos were recorded, totaling 549 minutes, including 454 minutes of lecture covering Chapter 6 of the textbook and 95 minutes of test solutions. Two tests, with 50 questions each, were administered to students.

Course Learning Objective 2. Critique heating and cooling options for building systems and determine the appropriated system and equipment. 15 videos were recorded, totaling 838 minutes, including 660 minutes of lecture covering Chapters 2, 3, 4, 5, and 6 contents and 178 minutes of test solutions. Four tests, with 50 questions each, were administered to students.

Course Learning Objective 3. Critique and compare methods of power production and transmission. 5 videos were recorded, totaling 266 minutes, including 266 minutes of lecture covering Chapter 10 and 11 contents and 49 minutes of test solutions. Two tests, with 50 questions each, were administered to students.

Course Learning Objective 4. Propose and evaluate equipment and materials necessary for power distribution. 6 videos were recorded, totaling 300 minutes, including 300 minutes of lecture covering Chapter 13 and 19 contents. Students were administered one test with 50 questions, and the solution was posted on Blackboard.

Course Learning Objective 5. Describe the system's equipment and processes of a fire protection design. 1 video was recorded, totaling 73 minutes, including 73 minutes of lecture covering Chapter 9 contents. Students were administered one test with 50 questions, and the solution was posted on blackboard.

Results

Mediasite Software: Viewing Results

Figure 1 represents viewing growth data that reveals a trend of continuously increased viewing from the beginning of the course towards the end of the course. The first two weeks show an average of 46 views per day, the middle week shows an average of 125 views per day, and the last two weeks average 567 views per day. The largest

viewership was 692 views per day during the final days of the course. Data indicated that, on average, each student accessed material once per day at the beginning of the course. Towards the end of the semester, this number increased to an average of 16 accesses per day per student. Increased viewings are also clustered around the release of tests, and data indicate that the amount of views increases the day tests are released. There was a significant increase in viewership from the beginning of the semester until the end, indicating that students became more engaged in the material.

Another interesting set of data provided by the MediaSite software is the number of times students access the videos on blackboard, shown by Figure 2. The composite data of views by day shows 44 users across 94 IP Addresses, totaling 136.41 hours, 692 views, and a peak of 76 views in one day. IP Addresses average 2.13 per student, indicating that students accessed the videos using more than one device. Comparing an individual trend to the entire class data, one specific student was captured viewing a specific video 8 times, and this will be revisited in the discussion.

Figures 3 and 4 compare the level of viewing intensity of an individual student with another individual student. Figure 3 shows that the only time of high intensity, for this student, is the one shown by a darker rectangle, 1 hour and 4 minutes of viewing time. For this specific point, the software shows the student opened the video on 5/17/1028 at 6:44 PM and remained active until 7:50 PM. Summing the amount of time active for this student reveals 95 minutes spent viewing this video, and the recorded time for this video is 68 minutes', which reveals 95/68= 139.7% of the coverage. However, the software calculates the coverage by comparing the time recorded with the time of high intensity used by the student, that is 64/68= 94.11% of coverage in this instance. The level of activity graphs shows a high correlation between low grades with a low level of activity. Figure 4 reveals the level of activity for the second video 002-Intro to Electricity, Part 2 for a student that earned a grade of F on the test covering the video's subject material. Data shows that the level of activity for this specific student was 2 minutes.

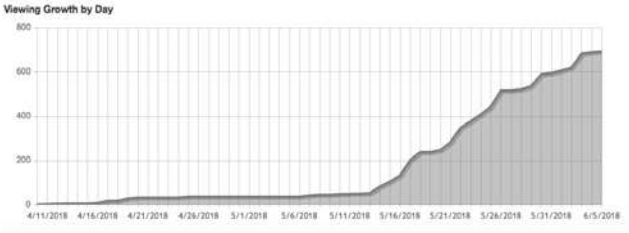

Figure 1: Viewing growth by day for 42 users.

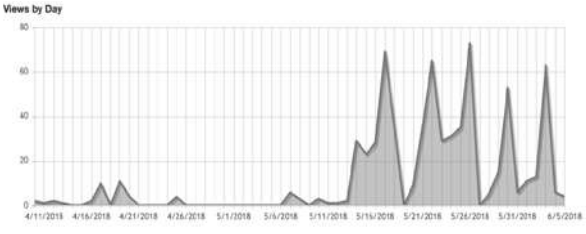

Figure 2: Views by day for 44 users.

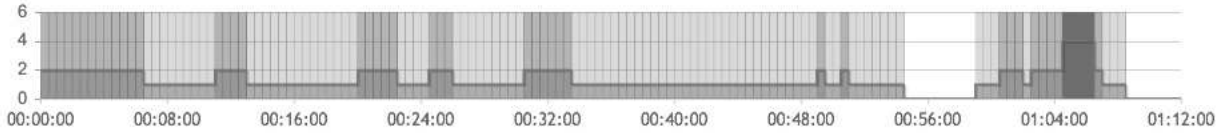

Figure 3: Level of activity for one student for the Intro to Electricity Class, Part 1.

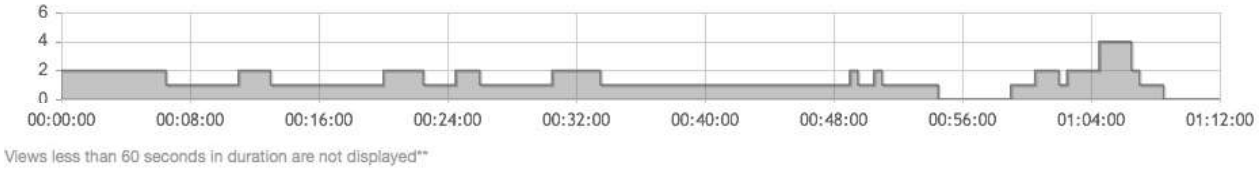

Figure 4: Level of Activity for one Student for the Intro to Electricity Class, Part 2.

Course Assessment

Course assessments were made using the results, analysis of results, and actions planned for next semester for each individual CLO. Overall, all goals relating to CLOs were achieved.

Course Learning Objective 1. 29/37 (78.37%) of the students received a grade of C or better, and this indicates the goal was met. An analysis of these results reveals that students tend to fail at interpolating data from the tables of estimation of probable demand for water in plumbing systems. For next semester, more time will be dedicated to teaching data extrapolation from tables that require this approach.

Course Learning Objective 2. 30/37 (81.08%) of the students received a grade of C or better, and this indicates the goal was met. An area students demonstrated difficulty in is the calculation of heat gain and heat losses of building elements and in the exchange heat of chillers installed in the refrigeration systems. In order to target this area, next semester, lecture time spent on heat load calculations will increase, as well as changing the format of test questions in this area. Lastly, actions are planned to increase the number of animations during lectures to reveal, in detail, the operation of chillers and interconnections of it with the refrigeration equipment.

Course Learning Objective 3. 32/37 (86.48%) of the students received a grade of C or better, and this indicates the goal was met. In general, students earned quality points in this section; the main deficiency identified is using formulas related to trigonometric functions. Next semester, the instructor will include a review of the basic trigonometric functions that can be applied to electric power formulas.

Course Learning Objective 4. 34/37 (91.89%) of the students received a grade of C or better, and this indicates the goal was met. Students achieved a high level of points on a majority of the test; however, some students demonstrated difficulty in selecting adequate formulas to perform calculations. Next semester, the instructor will include more practical problems using a variety of formulas to solve them.

Course Learning Objective 5. 36/37 (97.29%) of the students received a grade of C or better, and this indicates the goal was met. Students appear to have excelled in this section, and this might be due to the inclusion of film using a practical application of fire suppression systems. Since the students performed extremely well, next semester the instructor will increase the level of challenge on tests. Practical questions requiring students to provide and estimating of sprinklers required to cover a specific area will be included.

Student Grade Evaluation

A comparative analysis was performed between the online delivery class and the same F2F course from the Spring 2018 semester. The online course began with 40 students enrolled and 3 students withdrew in the first two days. The main justification provided by students for withdrawal was the number of hours currently being dedicated to job positions (approximately 12-16 hours per day, plus travel time to the job site). One student received an incomplete grade for the online course and was excluded from the analysis. The base number is 36 students for the online and F2F course, and Figure 5 shows students' grade distribution.

91.89% of students in the online delivery received a grade of C or higher, and this percentage is 88.88% for the F2F class. This reveals a greater percentage (3.01%) of students receiving a C or higher in the online portion than F2F delivery. Employing a Student's t-test to compare the grade distributions reveals a significance of $p < .001$, revealing the difference is significantly different. Additionally, using the criterion of "75% of the students will receive 75% or above on tests" as a measure of success, both course sections more than adequately met this goal. The grade distribution, as shown by Figure 9, reveals there is a greater concentration of grades for both classes at the higher-grade levels. There are also fewer students that obtained a grade of D in the online portion than F2F.

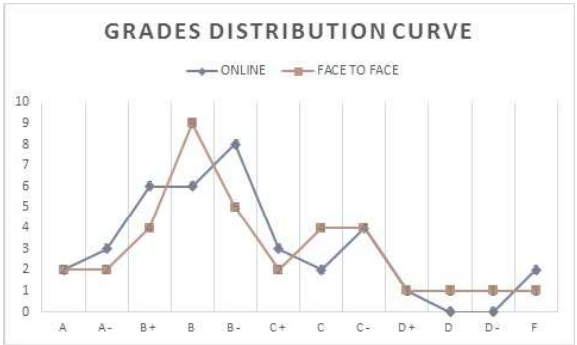

Figure 5: Student Grade Distribution

Discussion

Initially, an area of concern experienced while implementing the online program was student viewership. A library of videos dedicated to the MEP online course was created before the beginning of the semester, so videos could be posted at any point necessary. On the first day of the course, five of the videos were posted on Blackboard. Expectations were held that students would watch all of the films in preparation for the first test; however, as recorded by the MediaSite Software, this optimistic trend was lacking. Data shows online students starting to view videos on the same day they received homework assignments with a due date in the near future. In order to combat this habit, the instructor created more comprehensive homework, covering a wider range of material. The goal of this change was to increase motivation for students to view the videos and study the textbook. A frequent question asked by students was to display videos in a sequential order needed for specific tests, and this request was followed. Throughout the 10 assignments delivered, special directions were provided on which videos and subject matter to view in order to be successful on the test.

Another lesson learned from the online delivery involved the duration of lecture videos. Lectures with long durations appeared to lack attractiveness with students. Short duration videos were viewed in their entirety more often than long duration videos. The course utilized 2,403 hours of recorded material split across 41 videos. Ideally, it would be beneficial to spread the same amount of hours over 82 videos with a maximum of 30 minutes per video. This suggestion is derived from these observations comparing which lecture videos were most likely to hold the viewer's attention.

Students' results demonstrated that it is possible to successfully deliver a construction management course online in five weeks while covering the same material delivered in a traditional classroom setting. The comparative analysis between the online and F2F delivery reveals that online students performed just as well, if not slightly better, than students in the F2F class, and the grade distribution difference was statistically significant. The criterion of 75% of the students will earn a 75% or better was surpassed, as well. Although overall performance was adequate, there was a greater percentage of online students that received an F (5.4%) than the F2F class (2.7%). There was a portion of students in the online portion that neglected to submit assignments by the due date, or after the solution was posted, and this resulted in a negative impact on their grades. It is difficult to measure students' favorability of one format versus the other because surveys were not employed, but a student did mention the online version was preferred due to possessing unlimited access to the lecture contents.

One reason that the online delivery was so successful is the integration of the MediaSite Software. After video lectures and materials became visible to the students, they could watch the videos an unlimited amount of time. As compared to F2F classes where the lecture occurs once, the online students could view the lectures repeatedly. The MediaSite Software revealed this trend, and the data indicated that students accessed the same videos several times. Speculation is that the increased accessibility to viewing lectures allowed students to revisit material they were unsure of. Additionally, online students could manage the class to work around their work schedules. This was possibly more efficient than the enforcement of attendance in the F2F class because students perceive a greater sense of control over their studies.

With regards to the instructor, the ease of dealing less with students' absences and excuses of absences was relieving. Secondly, the process of recording videos to display for online delivery can be very time-consuming. Although this is a lengthy process, once a complete library of videos is obtained, they can be used repetitively throughout semesters. Also, all of the materials for the semester are prepared ahead of time, allowing for more time during the semester for the professor to dedicate to other tasks.

Conclusion

In Conclusion, the delivery of a Mechanical Electrical and Plumbing class online proved to be an effective way to reach students anywhere in the world, providing an opportunity to review all subjects of the course in accordance with personal needs. The quality of the material recorded by the MediaSite Software is superior when compared with traditional audio slides used for online courses, providing entire video lectures of the instructor and the material presented. The compatibility of the MediaSite Software with Blackboard is superb, and this integration allows for every component of the course to be effectively administered to students. The video library can consistently be updated, as well, and this provides continuous improvement in the quality of the course. This was a pilot class of an online MEP course at East Carolina University, and the instructor discovered encouraging results. The same level of performance and grades, if not slightly higher, was achieved in an online class when compared to a face-to-face class taught by the same professor with the same exact materials. Distance education was not a deterrent from obtaining the knowledge and skills necessary for learning MEP systems in buildings.

Due to the successful online delivery of a construction management class, future recommendations include expanding the reach of university classes beyond the boundaries of a classroom. There is a large population of workers in the construction field that want to expand their professional activities and obtain advanced careers through pursuing a construction management degree. It is difficult to achieve this degree while working a full-time job, and the option of an online CM program is a potential solution to this issue. The flexibility and control provided by the integration of MediaSite and Blackboard provide an excellent foundation for relaying necessary skills, techniques, and materials to those already in the field seeking to further their career.

References

Callister, R. R., & Love, M.S. (2016). A comparison of learning outcomes in skills-based courses: Online versus face-to-face formats. *Journal of Innovative Education, 14*(2), 243-256. doi:10.1111/dsji.12093

David, L. K., & Sung, C. H. (2009). Comparing student performance: Online versus blended versus face-to-face. *Journal of Asynchronous Learning Networks, 13*(1), 31-42. Retrieved from: http://jproxy.lib.ecu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=39248907&site=ehost-live&scope=site

Driscoll, A., Jicha, K., Hunt A. N., Tichavsky, L., & Thompson, G. (2012). Can online courses deliver in-class results? A comparison of student performance and satisfaction in an online versus a face-to-face introductory sociology course. *Teaching Sociology, 40*(4), 312-331. doi:10.1177/0092055X12446624

LaMeres, B. J., & Plumb, C. (2014). Comparing online to face-to-face delivery of undergraduate digital circuits content. *IEEE Transactions on Education, 57*(2), 99-106. doi:10.1109/TE.2013.2277031

Riley, D. R., Varadan, P., James, J. S., & Thomas, H. R. (2005). Benefit-cost metrics for design coordination of mechanical, electrical, and plumbing systems in multistory buildings. *Journal of Construction Engineering and Management, 131*(8), 877-889. doi:10.1061/(ASCE)0733-9364(2005)131:8(877)

Riley, J. M., Ellegood, W. A., Solomon, S., & Baker, J. (2017). How mode of delivery affects comprehension of an operations management simulation: Online vs face-to-face classrooms. *Journal of International Education in Business, 10*(2), 183-200. doi:10.1108/JIEB-09-2016-0025

Traphagan, T., Kussera, J. V., & Kishi, K. (2010). Impact of class lecture webcasting on attendance and learning. *Educational Technology Research and Development, 58*(1), 19-37. doi:10.1007/s11423-009-9128-7

Vasu, M. L., & Ozturk, A. O. (2008). A rich-media solution for distance education: A review of MediaSite. *Social Science Computer Review, 26*(4), 528-533. doi:10.1177/0894439308317652