AC 2009-1065: A COMPARISON OF ENGINEERING GRAPHICS COURSES DELIVERED FACE TO FACE, ON LINE, VIA SYNCHRONOUS DISTANCE EDUCATION, AND IN HYBRID FORMATS

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Comparison of Engineering Graphics Courses Delivered via Face-to-Face, Online, Synchronous Distance Education, and Hybrid Formats

Abstract

With the increase of online instruction in higher education, questions arise as to whether students acquire the necessary knowledge from a given course. This paper investigates the efficacy of four modes of delivery for an engineering graphics course. The four delivery modes are traditional face-to-face instruction, synchronous distance education using audiographics technology, asynchronous online instruction, and hybrid of face-to-face with asynchronous and synchronous online instruction. In general, each section of the course was delivered by the same instructor to undergraduate engineering students in their first or second year. In order to assess the effectiveness of each delivery mode, this research considers the observations of the instructor and the commentary from the students. Also, a posttest was given to students to assess their knowledge in basic areas of engineering graphics, including projections, visualization, and dimensioning. The results of this work will compare the effectiveness of the different modes of teaching. It should also offer some insight as to the different ways students learn engineering graphics and to what extent online instruction is appropriate for an engineering graphics course.

Introduction

As new education delivery technologies are developed, discussions arise as to whether these technologies are an effective way to educate students. With more institutions of higher education moving toward online instruction, the case must be made that the education students are receiving online is equivalent to the education received in a traditional format on campus. The move to alternative education technologies is growing in the field of engineering education. The paper considers the efficacy of an engineering graphics course offered in four different delivery modes.

Previous work has been done considering distance education in engineering graphics. A few examples include the use of a combination of synchronous and asynchronous technologies to deliver an engineering graphics course via distance education.[1] Totten and Branoff gave several strategies for a successful delivery of an online engineering graphics course.[2] In addition, Branoff and Wiebe considered the differences in student performance in face-to-face, online, and hybrid formats.[3] The work at hand considers four delivery methods of an engineering graphics course including face-to-face instruction, asynchronous online instruction, synchronous audiographics instruction, and a hybrid of online and face-to-face instruction. Student performance in each section will be compared to determine whether any delivery mode is better or worse than any other mode.

The paper will begin with a discussion of the course itself and a description the different modes in which it was delivered. That will be followed by an outline of the procedures used to acquire data. The analysis of this data will then be presented. Finally, some conclusions of the research will be offered.

Delivery Modes

This paper considers an engineering graphics course delivery using four different modes of delivery: traditional face-to-face instruction, asynchronous online instruction, a hybrid of face-to-face and online instruction, and synchronous audiographics instruction. This work occurred over a number of semesters and each mode was a separate section in which students enrolled based on what was offered to them. The different modes were offered based on the geographical location of the instructor as well as the students. Before detailing each delivery method, a brief outline of the course content is offered. The engineering graphics course consider here consists of three units: sketching, 2D CAD drawing, and 3D solid modeling. In the sketching unit, the basic concepts of engineering graphics are introduced through freehand sketching with paper and pencil. These concepts include projections, visualization, and dimensioning. Once the foundation of engineering graphics is taught, the course moves into drawing using a popular 2D CAD software package. In the final part of the course, students use 3D solid modeling software to create engineering drawings.

Face-to-face instruction is the traditional mode delivering an engineering graphics course. The face-to-face section in this study met twice a week for 120 minutes each class period. In the first 20 to 30 minutes of each class, the instructor delivered new content and demonstrated any application techniques. The rest of the time was spent as a lab, where students worked on drawings either by hand or at a computer. The instructor was available to answer questions as the students worked on drawings. A course website was used to post in-class notes, lab assignments, grades, and to offer a place to submit completed electronic drawings. There were 14 students in the face-to-face section.

The online delivery of the engineering graphics course was done on the internet using a widely-used learning management system. The course was available to students worldwide using this delivery mode; however, most students were from the home state of the institution offering the course. The content was delivered asynchronously, in that the instructor and the students need not be online simultaneously. The engineering graphics concepts were outlined using text and images. Drawing techniques, either by hand or using software, were demonstrated using web videos. A discussion board was used for students to post questions. Both students and the instructor participated in responding to postings on the discussion boards. Sketching assignments were scanned and submitted, while CAD assignments, both 2D and 3D, were submitted electronically. There were 10 students in the online section.

The engineering graphics course was also delivered via distance education using a synchronous audiographics setup. Like the face-to-face instruction, the class met twice a week for 120 minutes each time. In the first 20 to 30 minutes of presenting new material, web conferencing software was used to connect the instructor with several campuses. With this software, the instructor controls what the students see on the screen at each campus such as presentation slides and CAD software demonstrations. Also, a teleconference was established between the campuses to offer a real-time audio connection between the students and the instructor. After the lecture portion of the class, students moved to a computer lab and used another web conferencing program as a virtual lab. The virtual lab was essentially a chat room where the instructor could

again control what the students could see including the CAD software. In this chat room, students could ask questions about the lab on which they were working. The delivery mode also had a website similar to the one used in the face-to-face delivery. The synchronous audiographics section had 20 students.

The final mode of delivery used for the engineering graphics course was a hybrid of traditional face-to-face instruction and online content. This class met face-to-face once a week for 150 minutes. A brief discussion of material and techniques occurred at the beginning of class, but most of the time was spent as a lab answering students' questions on the given assignment. Most of the concepts and techniques were delivered using a website similar to the one used in the solely online delivery. In addition, to the face-to-face meeting, students could meet with the instructor in a chat room similar to the one used in the synchronous distance education delivery of the course. The instructor was available in this chat room for one 150-minute session per week. There were 23 students in the hybrid section of the course.

Procedure

The main tool used in assessing the efficacy of each delivery mode was a posttest of basic engineering graphics concepts. This posttest was created by the author and used in previous work determining the differences between students with previous engineering graphics experience and those with none.[4] Similar exams were created by others;[5,6] however, the author decided to use a self-created exam as it was the similar to one used in previous course offerings. The posttest consisted of 25 multiple-choice questions consisting of basic engineering graphics concepts such as projections, visualizations, section and auxiliary views, dimensioning, and working drawings. The test was given to all students at the end of the course. A student t-test was performed on the test results to compare each delivery mode to determine if there was a statistical difference in the scores between modes. For this study, no pretest was given; however, previous work did look at performance coming in to the course as well as at the end of the course.[4]

A similar statistical analysis was done on the grades from each of the labs completed in the course as was one for the posttest. Lab scores were the most relevant way to assess whether students could apply engineering graphics concepts to computer aided design software. The lab exercises were essentially identical in each of the delivery modes, therefore comparison of the lab scores was a relevant means in comparing the performance of students' application in each delivery mode. Also, since the same instructor taught the course in each of the modes, the instructor's perceptions of the differences between modes are also considered.

Results

The results from the assessment posttest are shown in Tables 1 and 2. Table 1 shows the percentage of correct answers on the posttest for each delivery mode. The scores are broken into five subtopics as well as the total score for the posttest. The audiographics section scored the best overall, while the online section scored the worst. Students did the best on projection theory while performing the worst on section and auxiliary views.

Table 1: Percentage of correct answers on posttest for each delivery mode and question type.

	Total	Projections	Visualization	Sections Auxiliaries	Dimensions	Working Drawings
Audiographics	76.9	88.0	77.8	63.3	75.6	77.8
Face-to-face	73.3	80.6	81.7	48.3	73.3	83.3
Online	64.0	76.2	74.3	48.6	57.1	60.7
Hybrid	69.9	84.9	65.7	52.4	66.7	78.6

While some general trends may be determined from looking at the raw scores in Table 1, to accurately compare the posttest results between delivery modes a t-test was performed on pairs of delivery modes. The t-test resulted in p-values revealing whether the posttest results of two delivery modes were statistically different. If the p-value is less than 0.05 for any combination of two modes, then the scores of those two modes are statistically different. Table 2 shows the p-values of each combination of two modes for each topic and the total posttest score. Nearly all of the p-values in Table 2 are greater than 0.05. Therefore, there is little difference in scores between modes of delivery. Another way of saying this is that students performed essentially the same on the posttest regardless of how they received the class. The two anomalies to this statement are the overall score for the audiographics delivery and the hybrid delivery. The overall score of 76.9 in the audiographics section was found to be statistically different from the 69.9 in the hybrid section. Overall, students in the audiographics section did better on the posttest than students in the hybrid section. Also, students in the face-to-face section did better on visualization than the students in the hybrid section. The sample size for this analysis was small (between 10 and 23 students). Using a larger sample size may or may not cause these results to change.

Table 2: P-values from t-test comparing posttest results for each delivery mode. Delivery modes posttest results are statistically different if less than 0.05.

	Total	Projections	Visualization	Sections Auxiliaries	Dimensions	Working Drawings
Audiographics vs Face-to-face	0.335	0.125	0.568	0.096	0.766	0.493
Audiographics vs Online	0.168	0.112	0.745	0.274	0.212	0.299
Audiographics vs Hybrid	0.039	0.377	0.086	0.142	0.188	0.924
Face-to-face vs Online	0.318	0.564	0.511	0.986	0.275	0.179
Face-to-face vs Hybrid	0.429	0.370	0.041	0.631	0.373	0.568
Online vs Hybrid	0.514	0.225	0.449	0.767	0.501	0.282

Analysis was also done on the lab assignments done by the students in each section. The average lab scores, in percent, for students in each delivery mode are shown in Table 3. Table 3 includes the overall lab score as well as the average scores in each of the three main topics covered in the course: sketching, 2D CAD, and 3D solid modeling. The face-to-face section had the highest overall lab score with a 79.1 while the online section scored the lowest with 68.2. In general, the scores decreased with each successive unit in the course. This decrease is likely due to students dropping the course or no longer participating, which resulted in those students receiving zeros for the labs due later in the semester, thus bringing down the class average. All delivery modes experienced some attrition during the course.

Table 3: Lab scores for each topic, in percentage, for each delivery mode

	Total	Sketching	2D CAD	Solid Modeling
Audiographics	76.0	79.1	78.1	72.5
Face-to-face	79.1	87.2	73.8	78.5
Online	68.2	77.1	68.0	63.1
Hybrid	77.6	85.4	76.2	74.1

As with the posttest, a t-test was performed on labs for each combination of two modes of delivery. Table 4 shows the p-values for each t-test performed on the overall lab scores as well as the scores from each of the units. If the p-value is greater than 0.05 then there is no difference in the lab scores between delivery modes. As can be seen from Table 4, all the p-values are greater than 0.05. Therefore, there is no statistical difference in the lab scores of each mode of delivery. Students performed statistically similar regardless of how the course content was delivered. Again, a larger sample size would give more convincing results.

Table 4: P-values from t-test comparing lab scores between different delivery modes. Delivery modes lab scores statistically different if value is less than 0.05.

	Total	Sketching	2D CAD	Solid Modeling
Audiographics vs Face-to-face	0.616	0.088	0.557	0.447
Audiographics vs Online	0.453	0.767	0.391	0.556
Audiographics vs Hybrid	0.816	0.242	0.803	0.850
Face-to-face vs Online	0.292	0.110	0.627	0.331
Face-to-face vs Hybrid	0.818	0.673	0.775	0.573
Online vs Hybrid	0.379	0.216	0.507	0.491

The final analysis of the delivery modes is the perception of the instructor. The author was the instructor for each section of the engineering graphics course. The instructor was surprised by the results of the study as it was thought there would be differences between the delivery modes. In general, the more student interaction the instructor had in a section, the more the instructor enjoyed the course. The instant feedback achieved with real-time discussion of problems resulted in a more rewarding experience for the instructor (and assumedly the student). This type of interaction was essentially non-existent in the online section of the course and at its greatest in the face-to-face section.

While attrition was a part of all sections, it was especially prevalent in the online section where approximately 40% of the students withdrew or stopped participating in the course. The other sections were typically in the 10% to 15% attrition rate. The was no clear reason the instructor could see as to why students dropped out of the online section more than in other modes. The reason may be as simple as the impersonal nature of asynchronous online delivery drove students away. It may also be that students found engineering graphics too challenging in the online environment. As can be seen from the results above, those students that stayed in the online sections performed equivalent to students in other sections.

While the instructor in this study disliked the online mode of delivery, it should be stated that another instructor may have the opposite reaction to the delivery modes. In fact, the instructor noticed many students seemed to prefer the asynchronous delivery mode even in the courses with synchronous components. A course website was utilized in all of the non-online sections and several students chose not to come to class to learn the material. These students heavily relied on the website and the textbook to complete the lab assignments. In fact, a few students never came to class after the first couple of days and continued to submit assignments and do well in the course.

There does seem to be a need and a desire for online courses. While this instructor does not prefer this mode, others might. The preliminary data presented here suggests that students can learn the concepts in an engineering graphics course and be successful at learning CAD software regardless of how the course is delivered to them.

Conclusion

The work presented here considered the efficacy of an engineering graphics course offered in four different modes. The course was taught in a traditional face-to-face setup, online, using a synchronous audiographics delivery, and a hybrid of face-to-face and online. To determine how well the students did in each mode, a posttest covering basic engineering concepts was given as well as an analysis of lab scores between delivery modes. In general, no statistical difference was found in the performance metrics between delivery modes. Students performed essentially the same on the posttest and labs no matter how they received the course. Despite the small sample size used in this preliminary study, there is certainly potential that students will learn the necessary skills in an engineering graphics course regardless of the delivery mode used.

Future work could consist of continuing to gather data from different delivery modes to increase the significance of the results. Another aspect of the study for future consideration would be to look into the reasons behind the significantly large dropout rate in the online delivery method.

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