AC 2009-249: LARGE COURSE REDESIGN: REVISING AN INTRODUCTORY ENGINEERING GRAPHICS COURSE TO MOVE FROM FACE-TO-FACE TO HYBRID INSTRUCTION

Theodore Branoff, North Carolina State University

Ted Branoff is an Associate Professor in the Department of Mathematics, Science and Technology Education at North Carolina State University. He received a bachelor of science in Technical Education in 1985, a master of science in Occupational Education in 1989, and a Ph.D. in Curriculum and Instruction in 1998. A member of ASEE since 1987, Ted has served as Chair of the Engineering Design Graphics Division of ASEE and as Associate Editor in charge of paper reviews for the Engineering Design Graphics Journal. He is currently president of the International Society for Geometry and Graphics. His research interests include the effects of online instruction for preparing technology education teachers and engineers. Along with teaching courses in engineering graphics, computer-aided design, descriptive geometry, and instructional design, he has conducted CAD and geometric dimensioning & tolerancing workshops for both high school teachers and local industry.

Large Course Redesign: Revising an Introductory Engineering Graphics Course to Move from Face-to-Face to Hybrid Instruction

Abstract

In the fall of 2007, faculty in the Department of Mathematics, Science and Technology Education began piloting hybrid or blended instruction in their introductory engineering graphics course. The asynchronous, online components of the course consist of voiced-over content presentations, software demonstrations, and sketching videos. During the weekly face-to-face meetings, faculty highlighted the important concepts for the next lesson, gave brief constraint-based CAD demonstrations, covered ideation and technical sketching techniques, and checked homework. Faculty found that students used a variety of different strategies to complete the textbook material, solid modeling assignments, and sketching assignments. No difference was found between the final exam scores in the hybrid sections and the face-to-face sections. During the fall 2008 semester, faculty conducted another pilot study with a different faculty member teaching two of three hybrid sections. The same methodology was used for presenting the content, SolidWorks demonstrations, and sketching demonstrations. The analysis of midterm exam scores and final course grades revealed no difference between the hybrid and face-to-face sections. Students in the hybrid sections scored significantly higher on the final exam than students in the face-to-face sections. This effort is part of a Large Course Redesign Grant from the university to help convert all sections of the course to hybrid instruction. Key components of the redesign include revising online streaming media, moving online content from WebCT to Moodle, conducting synchronous online help sessions, and developing an automated grading system for constraint-based CAD files. This paper summarizes the previous research conducted in the introductory course, presents data from the fall 2008 semester, and describes the plan for the whole course revision.

Introduction

When implemented correctly, an effective alternative to face-to-face or completely online instruction is hybrid or blended instruction. Some of the potential benefits are equivalent or improved instruction, an engaged model of learning, accelerated completion of courses, self-paced or personalized instruction, reduced drop-out and re-enrollments in the same course, and reduction of course duplication and redundancy [1]. In addition, well planned blended learning environments potentially may improve pedagogy, increase accessibility and flexibility, and increase cost effectiveness [2]. Blended learning also shifts the responsibility of learning from the instructor to the student. It lets students engage difficult material when they are ready, for as long or as little as necessary. This allows faculty to focus on the application of knowledge during face-to-face meetings [3].

There are some concerns that must be addressed when using blended or hybrid instruction. One mistake that many instructors make is taking the content from a face-to-face course and moving it directly online. Most courses need to be redesigned to take advantage of online technologies that can transform learning [4]. In addition to not using a formal instructional design process to

develop online materials, other reasons why blended learning environments sometimes fail include poorly trained faculty to facilitate or implement courses, lack of support from administration, and inexperienced online learners [5]. Faculty who are moving courses to a blended learning environment should also be aware that many of their students may have already participated in courses where some or all of the instruction was online. Students expect online materials to be up-to-date, they want to feel "instructor presence" while online [6], and they expect timely feedback on homework assignments and discussion posts [7].

Over the last several years, faculty in the Department of Mathematics, Science and Technology Education have been developing blended learning courses in the Graphic Communications Program. During the fall of 2007, three sections of an introductory engineering graphics course were taught using a blended or hybrid environment [8]. Faculty developed Flash videos of voiced-over PowerPoints, sketching demonstrations, and SolidWorks demonstrations to deliver the textbook and CAD content online for the course. Study guides were made available in a pdf format, and students were required each week to complete a 10-20 question WebCT Vista quiz to assess their learning of the textbook material. Since the online materials were organized on course web pages, students had a great deal of flexibility when navigating the content. As a result, there were 19 different strategies used by students to work through the textbook material, 20 strategies for completing the SolidWorks assignments, and 15 strategies for completing the sketching assignments. Faculty also compared performance on the final exam between the hybrid sections and the face-to-face sections. Students in the hybrid sections scored slightly higher on the final exam than students in the face-to-face sections, but this difference was not significant. As far as the textbook content for the course, it appeared that students in the hybrid sections understood the material just as well as students in the face-to-face sections.

Methodology – Fall 2008 Study

The intent of the fall 2008 study was to replicate the methodology of the fall 2007 study involving at least one new faculty member. Three sections of GC120, Foundations of Graphics (74 students), were taught as a hybrid or blended instruction course. Two hybrid sections were taught by a faculty member who was not involved in the fall 2007 study. The other section was taught by the lead author of this paper. Content for the course was organized the same as the fall 2007 study within a series of lesson pages (see Figure 1). Content for the hybrid introductory engineering graphics course was delivered in several formats. Flash videos of voiced-over PowerPoints (Figure 2), sketching demonstrations (Figure 3), and SolidWorks demonstrations (Figure 4) were created to deliver the textbook and CAD content for the course. SolidWorks videos were updated during the summer of 2008 to reflect the current version of the software. Study guides were made available in a pdf format, and students were required each week to complete a 10-20 question WebCT Vista assessment (Figure 5).

Students in all hybrid sections of the course were required to have a laptop computer with wireless capabilities. SolidWorks was installed on the students' laptops, but the software only functioned if the computer was able to access a campus license server. One of the hybrid sections was moved to a computer laboratory after one week of class when the laboratory became available. The instructor and the students preferred the laboratory over the classroom since the classroom only had two outlets and had less square footage than the computer laboratory.

Lesson 5 - Cylinders & Holes

Textbook Material

- Read Sections 5.8-5.9 in Chapter 5 and Sections 7.4-7.11 in Chapter 7.
- Material from Chapter 5 - *9:57*
- Material from Chapter 7 - *5:51*
- Lesson 5 Quiz - *Complete by 8:00am on September 24.*

SolidWorks Modeling Activities

- Modeling the HINGED CATCH, Problem 4, page 383 - *6:12* - *Due September 29 at 6:00am in your locker workspace.*
- Creating a drawing of the HINGED CATCH - *8:03* - *Due September 29 at 6:00am in your locker workspace.*

Sketching Activities

- Sketching Example 3a - Circles-Good and bad examples - *5:52*
- Sketching Example 3b - Circles-Large circles - *3:06*
- Sketching Example 4 - Ellipses-Sketching on square grid - *5:03*
- Sketching an isometric ellipse - *3:04*
- Sketching Example 7 - Isometric Ellipses-Circular pictorial features - *10:32*
- ORT 050 - *Completed worksheet due in class on September 24.*
  - Object #1 (eDrawing - Use Internet Explorer)
  - Object #2
  - Object #3
  - Object #4
- ISO 040 - *Completed worksheet due in class on September 24.*
  - Top object
  - Bottom object

Figure 1. Example of a Lesson Webpage.

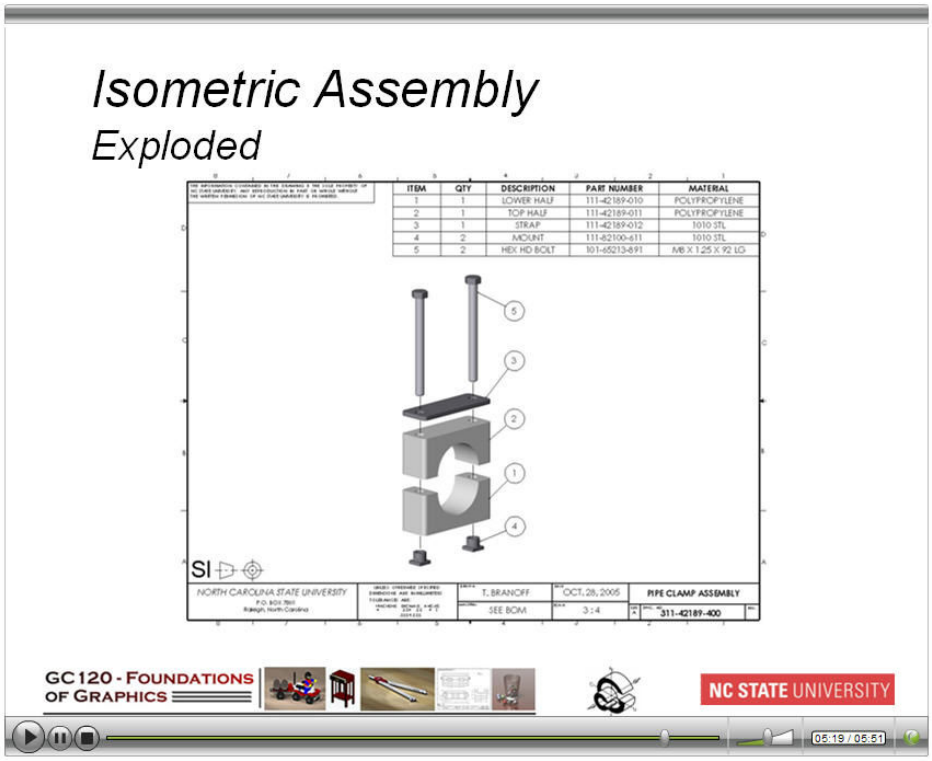


Figure 2. Example of Voiced-Over PowerPoint.

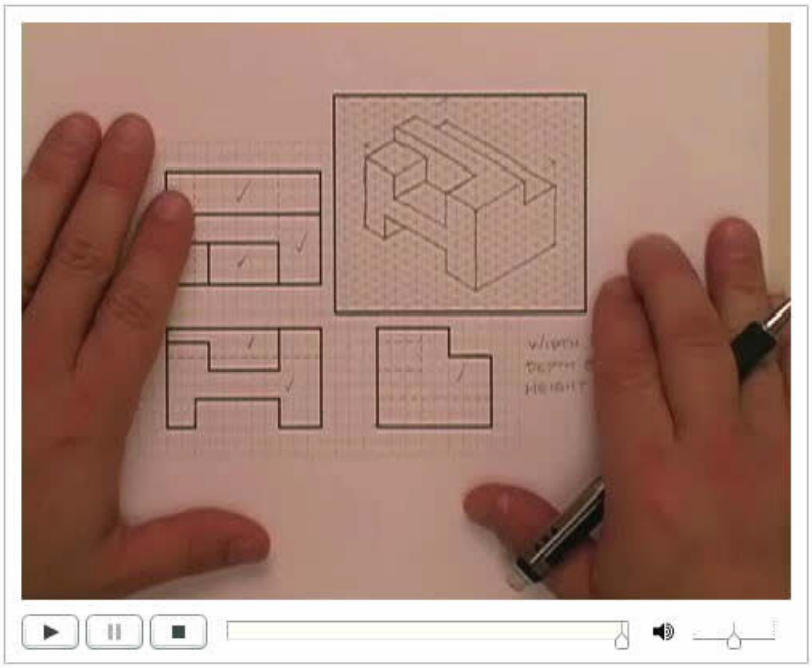


Figure 3. Example of Sketching Video.

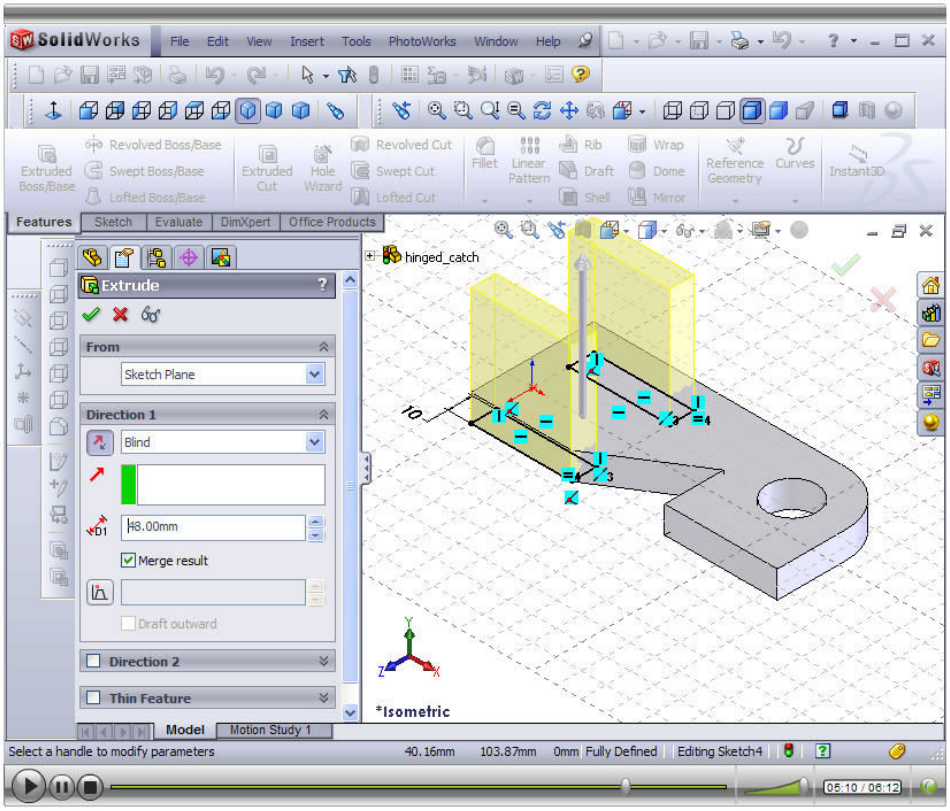
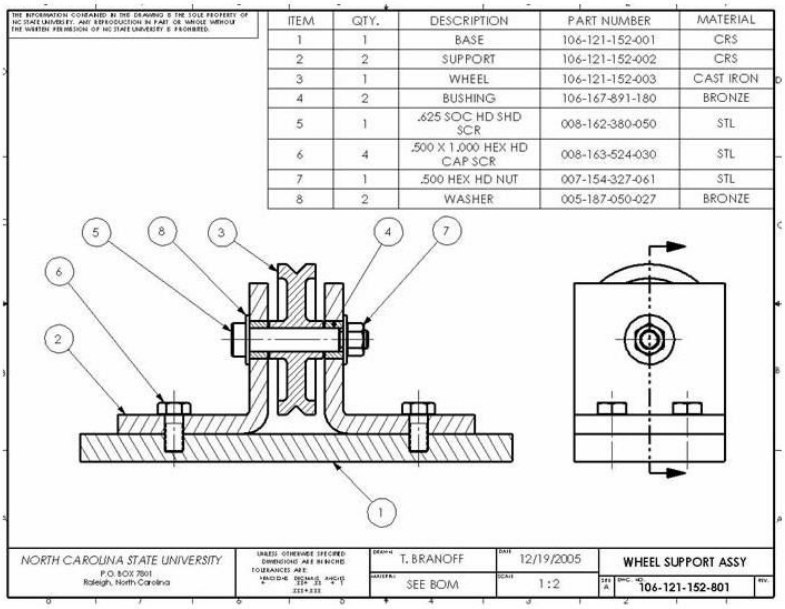


Figure 4. Example of a SolidWorks Demonstration Video.

8. Question 10.8 (Points: 10)

Which part in the assembly below is made of cast iron?



ITEM	QTY.	DESCRIPTION	PART NUMBER	MATERIAL
1	1	BASE	106-121-152-001	CRS
2	2	SUPPORT	106-121-152-002	CRS
3	1	WHEEL	106-121-152-003	CAST IRON
4	2	BUSHING	106-167-891-180	BRONZE
5	1	.625 SOC HD SHD SCR	008-162-380-050	STL
6	4	.500 X 1.000 HEX HD CAP SCR	008-163-524-030	STL
7	1	.500 HEX HD NUT	007-154-327-061	STL
8	2	WASHER	005-187-050-027	BRONZE

NORTH CAROLINA STATE UNIVERSITY
P.O. BOX 7901
Raleigh, North Carolina

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONAL ± ANGULAR ± .XX ± .XXX

DRAWN: T. BRANOFF | DATE: 12/19/2005 | WHEEL SUPPORT ASSY
MATERIAL: SEE BOM | SCALE: 1:2 | SIZE: A | DWG. NO. 106-121-152-801 | REV.

- ○ 1. .625 SOC HD SHD SCREW
- ○ 2. BASE
- ○ 3. SUPPORT
- ○ 4. WHEEL

Save Answer

Figure 5. Example of a WebCT-Vista Assessment.

The face-to-face sections met twice per week for one hour and fifty minutes or once per week for 4 hours. The hybrid sections met face-to-face only once per week for one hour and fifty minutes. The instructors of the hybrid sections used the class time to discuss and demonstrate key solid modeling topics, check homework, and answer questions about assignments. Students were required to view the online content before coming to class. They also completed most of the sketching activities outside of class. During the thirteenth week of the fall semester, students were asked to complete a confidential survey which was used to assess their preferences for instruction and evaluate their learning strategies. The survey included the following questions:

1. Have you ever taken an online course?
2. Have you ever taken a hybrid course?
3. What is your instructional preference?
4. In what general order did you complete the online material related to the textbook?
5. If you were not required to complete the WebCT Vista assessments, what would be your approach for doing the readings?
6. In what general order did you complete the modeling assignments?
7. What is your preference for solid modeling instruction?
8. In what order did you complete the sketching assignments?
9. What is your academic year?
10. What is your major?

Results

Sixty-nine students (95%) completed the survey. Table 1 shows the academic year of the students. Table 2 displays a summary of their academic majors.

Table 1. Academic Year.

Year	Frequency	Percent
Freshmen	0	0%
Sophomore	58	84 %
Junior	10	15%
Senior	1	1%
TOTAL	69	100%

Table 2. Academic Major.

Major	Frequency	Percent
Aerospace Engineering	9	13%
Civil Engineering	19	28%
Computer Science	2	3%
Electrical Engineering	2	3%
Electrical & Computer Engineering	1	1%
Engineering Undesignated	3	4%
Environmental Engineering	2	3%
Industrial Engineering	2	3%
Mechanical Engineering	28	41%
Political Science	1	1%
TOTAL	69	100%

A majority of the students in the study were sophomores since GC120 falls in the sophomore year for most of the participants. Although the course is open to anyone at the university, the data in Table 2 indicate that enrollment favors engineering majors.

Students were also asked if they were ever enrolled in any hybrid or completely online courses. Tables 3 & 4 summarize this data.

Table 3. Previously Taken an Online Course.

Yes/No	Frequency	Percent
Yes	15	22%
No	54	78%
TOTAL	69	100%

Table 4. Previously Taken a Hybrid Course.

Yes/No	Frequency	Percent
Yes	19	28%
No	50	72%
TOTAL	69	100%

Twenty-two percent of students had taken or were taking an online course. Twenty-eight percent had taken or were taking a hybrid course (other than GC120).

Students were also asked whether they preferred face-to-face, online, or hybrid instruction. Table 5 shows the results of their instructional preference.

Table 5. Instructional Preference.

Instruction	Frequency	Percent
Face-to-face	25	36%
Hybrid	40	58%
Online	3	4%
Left item blank	1	2%
TOTAL	69	100%

Fifty-eight percent of students preferred a hybrid course, and just over one third preferred face-to-face instruction. Only three students preferred completely online instruction.

Students were also asked to determine the order in which they completed the online material related to the textbook, the solid modeling assignments, and the sketching assignments.

Students studied the textbook material using twelve different strategies. The top three were:

1. Reviewed the textbook material and then completed the online assessment (25%).
2. Watched the streaming videos, read/reviewed the textbook, and then took the online assessment (16%).
3. Read and reviewed the textbook and then took the online assessment (15%).

Students completed the solid modeling assignments using 9 different strategies. The top three were:

1. Took notes during the in-class demonstration, watched the streaming video demonstrations, modeled the object in the video, and then modeled the second assigned object (35%).
2. Watched the streaming video demonstration, modeled the object in the video, and then modeled the second assigned object (23%).
3. Modeled the object in the video while watching the video, and then modeled the second assigned object (7%).

There were 11 different strategies used by students to complete the sketching activities. The top three were:

1. Started the sketching assignment in class, and then finished the assignment outside of class (39%).
2. Viewed some of the sketching videos, and then completed the assignment outside of class (17%).
3. Started the sketching assignment in class, viewed some of the online videos, and then completed the assignment outside of class (13%).

In addition to these analyses, midterm exam scores, final exam scores, and final grades between face-to-face sections and the three hybrid sections were compared. The midterm exam was a combination of multiple-choice, fill in the blank, and sketching items. The final exam was 100 multiple-choice questions. Approximately 15% of the final exam questions required students to visualize and select a correct view of an object. For both exams and the final course grade it was hypothesized that there would be no difference between the face-to-face sections and the hybrid sections at the $\alpha=0.05$ level. Since the sample sizes were different and a normal distribution was not assumed, a Wilcoxon, Mann-Whitney U test was used to determine if significant differences existed between the groups. Table 6 displays the midterm exam means for each group, and Table 7 shows the results of the Wilcoxon, Mann-Whitney U analysis. Table 8 displays the final exam means for each group, and Table 9 shows the results of the Wilcoxon, Mann-Whitney U analysis.

Table 6. Midterm Exam Means for Face-to-face and Hybrid Sections.

Group	N	Mean	Std. Dev.	Minimum	Maximum
Hybrid	73	85.10	8.74	42	98
Face-to-face	177	85.66	7.86	56	99

Table 7. Wilcoxon, Mann-Whitney U (Rank Sums) for Midterm Exam Scores.

Group	N	Sum of Scores	Exp. Under H0	Std Dev	Mean Score
Hybrid	73	8935.50	9161.50	519.25	122.40
Face-to-face	177	22439.50	22213.50	519.25	126.78

Wilcoxon Two-Sample Test Statistic	8935.50	
Normal Approximation		
Z	-0.4343	
One-Sided Pr > Z	0.3322	
Two-Sided Pr > |Z|	0.6641	

Table 8. Final Exam Means for Face-to-face and Hybrid Sections.

Group	N	Mean	Std. Dev.	Minimum	Maximum
Hybrid	73	86.30	7.96	56	98
Face-to-face	177	80.19	9.41	48	97

Table 9. Wilcoxon, Mann-Whitney U (Rank Sums) for Final Exam Scores.

Group	N	Sum of Scores	Exp. Under H0	Std Dev	Mean Score
Hybrid	73	11638.00	6131.50	519.53	159.42
Face-to-face	177	19737.00	22213.50	519.53	111.51

Wilcoxon Two-Sample Test Statistic	111638.00	
Normal Approximation		
Z	4.7658	
One-Sided Pr > Z	< .0001 *	
Two-Sided Pr > |Z|	< .0001 *	

* Significant at $\alpha=0.05$

The midterm exam mean for the hybrid sections was 85.10 and the midterm exam mean for the face-to-face sections was 85.66. This difference was not significant at the α=0.05 level. The final exam mean for the hybrid sections was 86.30 and the final exam mean for the face-to-face sections was 80.19. The analysis revealed that this difference was significant at the α=0.05 level (Z=4.7658, p<.0001).

Figure 6 shows the grade distributions for the hybrid and face-to-face sections. Table 10 shows the results of the Wilcoxon, Mann-Whitney U analysis.

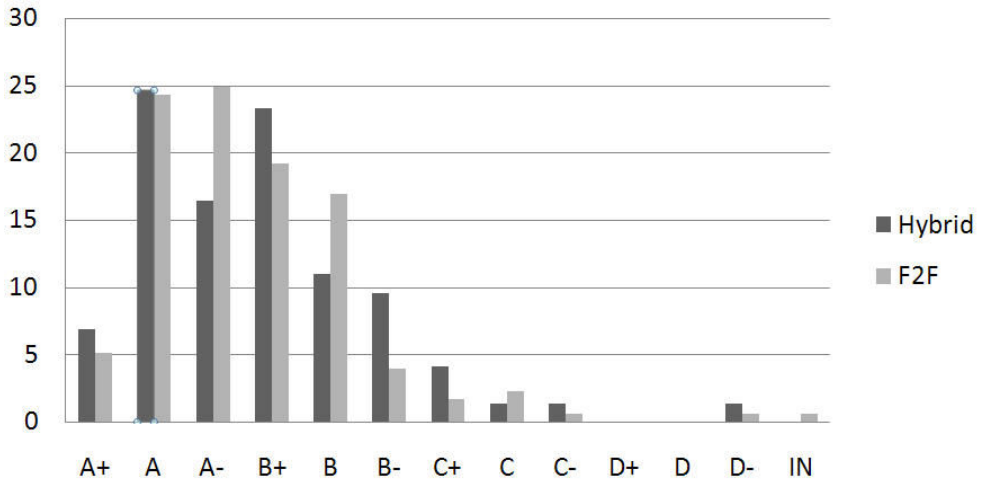


Figure 6. Final Grade Distributions for the Hybrid and Face-to-Face Groups.

Table 10. Wilcoxon, Mann-Whitney U (Rank Sums) for Final Course Grades.

Group	N	Sum of Scores	Exp. Under H0	Std Dev	Mean Score
Hybrid	73	9413.50	9161.50	509.86	128.95
Face-to-face	177	21961.50	22213.50	509.86	124.08

Wilcoxon Two-Sample Test Statistic		9413.50
Normal Approximation		
Z	0.4933	
One-Sided Pr > Z	0.3109	
Two-Sided Pr > |Z|	0.6218	

The analysis of the final grades revealed no significant difference between the hybrid and face-to-face groups.

Discussion and Conclusions

Similar to the fall 2007 study, students used multiple strategies for completing the assignments. The fall 2008 data revealed that more students elected not to use the online streaming videos to complete work. Thirty-nine percent of students used strategies for studying the textbook material that did not involve using the streaming media. This was up from 13% during the fall 2007

study. In the current study, less than 5% of students reported preparation strategies for the online assessments that did not include reading or reviewing the textbook. Less than 10% of students used strategies that did not include watching video demonstrations for the SolidWorks assignments. This was similar to the previous study. Approximately 46% of students did not view videos to help complete their sketching assignments. This was more than double the number of students from the fall 2007 study. The variable that might explain some of this variation was instructors of the sections. The current study involved only one faculty member who taught during the previous study. Strategies used by one of the faculty during the face-to-face meetings may have included more emphasis on sketching activities during class rather than relying on online materials.

Since the links for the streaming media were organized on a course web page, students could navigate through the materials in any order. Within this format, faculty could not track the order or the amount of time spent within the site. This also could account for the number of students who did not elect to use the online materials. Placing these links within a learning management system will allow faculty to track student progress more accurately.

Analyses revealed no significant differences between the hybrid and face-to-face sections for midterm exam scores or final course grades. Students in the hybrid sections, however, did score significantly higher on the final exam than students in the face-to-face sections. One possible explanation for finding a difference on the final exam and not the midterm may be based on the types of questions given on each exam. Since students in the hybrid sections completed weekly online assessments of between 10-20 multiple-choice items, it is possible that this practice gave them an edge over students in the face-to-face sections on the 100 multiple-choice question final exam. Only 25% of the midterm exam consisted of multiple-choice items.

Future Work

As part of a Large Course Redesign Grant, several additional changes will take place for the spring 2009 semester. First, all of the course materials will be accessed by students through the Moodle learning management system (Figure 7). This will allow instructors to track student progress while also giving them the option to show links only after students have completed other assignments. This creates more of a learner centered approach to the course. Students will have control over when they view the online content as well as options for viewing content more than once.

Another addition to the course is an automated system for evaluating SolidWorks assignments similar to what has been done at Rensselaer Polytechnic Institute [9, 10]. Currently faculty must open each student's file and view individual features and sketches to determine if the model is correct. The automated grading system will allow students to submit their file and obtain automated feedback on the correctness of their models based on faculty selected features. This innovation will drastically reduce the amount of time faculty spend evaluating assignments and will also give students more control of their own learning.

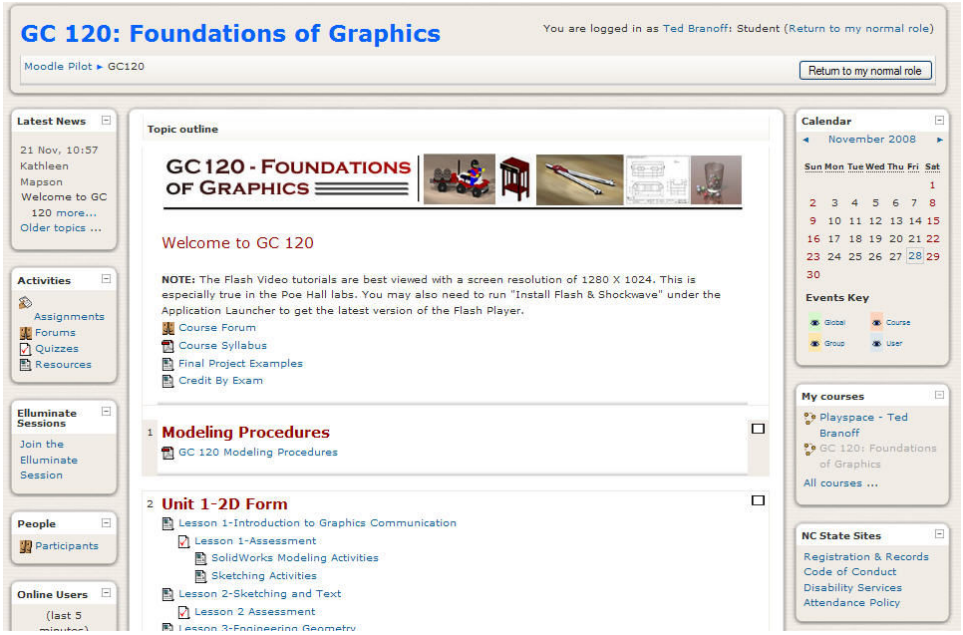


Figure 7. GC120 within the Moodle Learning Management System.

Bibliography

1. Marsh, G. E., McFadden, A. C., & Price, B. J. (2003). Blended instruction: Adapting conventional instruction for large classes. *Online Journal of Distance Learning Administration*, 6(4). Retrieved November 7, 2008 from, http://www.westga.edu/~distance/ojdla/winter64/marsh64.htm
2. Graham, C. R. (2005). Blended learning systems: Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs.* (pp. 3-21). San Francisco, CA: Pfeiffer Publishing.
3. Huguet, M. P., Haley, T., Baltaci-Goktalay, S. (2008). From electrons to neutrons – Blended engineering education. *Proceedings of the ASEE Zone I Conference, United States Military Academy, West Point, NY, March 28-29, 2008,* 1-9.
4. Murphy, P. (December, 2002). *The hybrid strategy: Blending face-to-face with virtual instruction to improve large lecture courses*. Retrieved November 7, 2008, from http://www.ucop.edu/tltc/news/2002/12/feature.php
5. Hofmann, J. (2005). Why blended learning hasn't (yet) fulfilled its promises: Answers to those questions that keep you up at night. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs.* (pp. 27-40). San Francisco, CA: Pfeiffer Publishing.
6. Condone, S. (2004). Reducing the distance: A study of course websites as a means to create a total learning space in traditional courses. *IEEE Transaction on Professional Communication, 47*(3), 190-199.
7. Geng, H., Au, W., & Yates, G. (2007). Investigation of the supports from teachers that influence the interaction between students and teachers. In T. Hiresahima, U. Hoppe, & S. Young (Eds.), *Supporting learning flow through integrative technologies*. (205-212). Amsterdam: IOS Press.
8. Branoff, T. J., & Wiebe, E. N. (2008). Face-to-face, hybrid or online?: Issues faculty face in redesigning an introductory engineering graphics course. *Proceedings of the 2008 Annual Meeting of the American Society for Engineering Education, Pittsburgh, Pennsylvania,* June 22-25, 2008.
9. Baxter, D.H. (2003). Evaluating an automatic grading system for an introductory computer aided design course. *Proceedings of the 58th Annual Midyear Conference of the Engineering Design Graphics Division of the American Society for Engineering Education, Scottsdale, Arizona, November 16-19, 2003*.
10. Baxter, D.H. & Guerci, M. J. (2003). Automating an introductory computer aided design course to improve student evaluation. *Proceedings of the 2003 Annual Conference of the American Society for Engineering Education, Nashville, Tennessee, June 22-25, 2003*.