

Blended Instruction in an Introductory Engineering Graphics Course

Theodore J. Branoff

*Department of Mathematics, Science and Technology Education
Raleigh, North Carolina 27695-7801*

Walter F. Kelly, Jr.

*Department of Mathematics, Science and Technology Education
Raleigh, North Carolina 27695-7801*

ABSTRACT - In a continuing effort to improve instruction, the faculty at North Carolina State University has made several major revisions to their introductory engineering graphics course. First, the course format has been changed from face-to-face to blended learning. Classroom instructional time has been reduced by 50%, and students are now responsible for going through online course content outside of class time. A second revision is that this online content has been moved from open web pages with online assessments in the Blackboard learning management system (LMS) to the Moodle open source LMS. Some of the reasons for moving to Moodle include: providing a vehicle to organize course content in an efficient manner; being able to track student progress through the instructional units; providing students with feedback on their learning through online assessments; and allowing the faculty to provide consistent instruction over all sections of the course. In addition to these two revisions, an automated grader for SolidWorks files has been developed and will be implemented in the 2009 fall semester. This paper summarizes previous research conducted in the course, presents data from the 2009 spring semester, and

describes technologies that have been added to the course to improve instruction.

I. Introduction

Over the last two years, faculty in the Department of Mathematics, Science and Technology Education have been revising their Foundations of Graphics course to move from a face-to-face environment to a blended learning environment. This is consistent with other programs around the country who are addressing reduced resources in addition to looking for ways to improve instruction (Holdhusen, 2009; Baxter, 2003). Reasons for the change include: continuously searching for the most effective instruction; investigating more cost effective ways of delivering course content; making the best use of classrooms and computer laboratories; and giving students more control of their learning. During several pilot studies of blended learning in this course, content was organized by units and lessons in a series of web pages. Content consisted of voiced-over presentations of textbook material, review sheets, software demonstrations, sketching demonstrations, and low-stake assessments in WebCT and Blackboard. Students could navigate through these pages in any order, and faculty received little feedback

concerning how much time students were engaging the material outside of class. Analyses of several measures revealed that students in the blended learning sections performed just as well as students in the face-to-face sections on the midterm exam, the final exam, and in the overall course (Branoff & Mapson, 2009; Branoff, 2008; Branoff & Wiebe, 2008; Branoff & Wiebe, 2007).

II. Methodology

The intent for the Spring 2009 semester was to examine the effectiveness of teaching GC120 – Foundations of Graphics in a blended format with content organized within the Moodle course management system. During the semester two instructors taught six sections of the course using the blended format while five other instructors taught nine sections using a face-to-face format. One of these instructors did not report his end-of-course information, so all data for the face-to-face sections is based on four instructors covering seven sections. Table 1 displays the distribution of students between the two groups.

Table 1. Spring 2009 GC120 Student Numbers.

GC120 Sections	Number of Students
Face-to-Face Sections	164
Blended Learning Sections	128

The blended learning sections of the course met once per week for approximately 2 hours, while the face-to-face sections met for approximately 4 hours per week. Instructors in the blended learning sections used their weekly meetings to introduce the main concepts for the week, answer questions about homework, and check some homework. Students in the blended learning sections were expected to view and complete online content outside of class time. The online content was organized by units on the main course page within

Moodle (see Figure 1). Students could then access lesson pages corresponding to textbook chapters (Figure 2), SolidWorks modeling activities (Figure 3), and sketching exercises (Figure 4). Most of the lesson pages included links to streaming media. For textbook chapters, this consisted of voiced-over PowerPoint presentations. The SolidWorks activities pages included streaming media demonstrations of part modeling, assembly modeling or drawing creation. The sketching pages included streaming video of an instructor sketching the assigned activity. At the end of each lesson students were required to complete a 10-20 item online assessment as a check of their content knowledge understanding (see Figure 5).



Figure 1. GC120 Moodle Unit Structure.

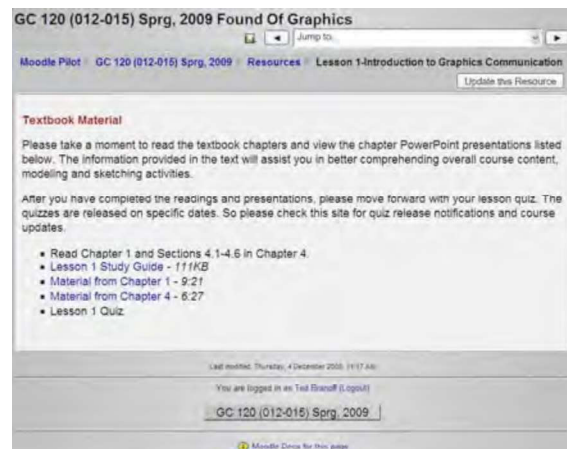


Figure 2. Moodle Textbook Lesson Page.

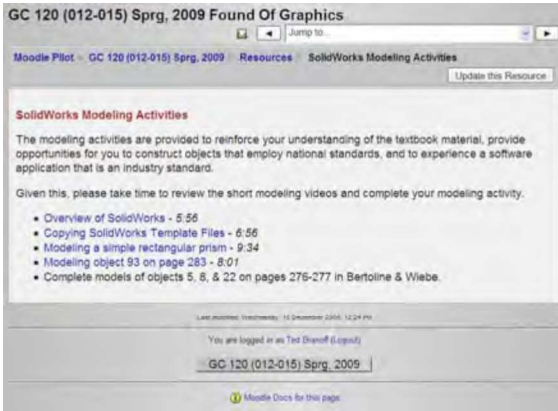


Figure 3. Moodle SolidWorks Activities Page.



Figure 4. Moodle Sketching Activities Page.

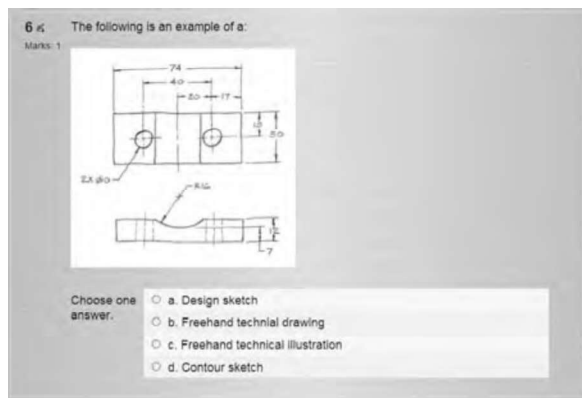


Figure 5. Example of an Online Assessment Item.

III. Analyses

Three measures were used to determine if students in the blended sections of GC120 were performing as well as students in the face-to-face (F2F) sections – the midterm exam, the final exam, and the final course grade. 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. Tables 2-4 show the means, standard deviations, and ranges for each of these measures.

Table 2. Midterm Exam Means.

Group	N	Mean	SD	Min	Max
F2F	164	88.40	8.31	51	100
Blended	128	86.59	6.68	0	97

Table 3. Final Exam Means.

Group	N	Mean	SD	Min	Max
F2F	164	78.26	13.35	0	94
Blended	128	77.69	13.78	0	97

Table 4. Course Grade Means.

Group	N	Mean	SD	Min	Max
F2F	164	88.84	7.98	39	98
Blended	128	86.59	11.52	32	100

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. Tables 5-7 show the results of the Wilcoxon, Mann-Whitney U analyses.

Table 5. Wilcoxon, Mann-Whitney U (Rank Sums) for Midterm Exam Scores.

Group	N	Sum of Scores	Exp. Under H_0	SD	Mean Score
F2F	164	26216.50	24026.00	715.05	159.86
Blended	128	16561.50	18752.00	715.05	129.39
Wilcoxon Two-Sample Test Statistic				16561.50	
Normal Approximation					
Z				-3.0627	
One-Sided Pr < Z				0.0011 *	
Two-Sided Pr > Z				0.0022 *	
* Significant at $\alpha=0.05$					

Table 6. Wilcoxon, Mann-Whitney U (Rank Sums) for Final Exam Scores.

Group	N	Sum of Scores	Exp. Under H_0	SD	Mean Score
F2F	164	24196.50	24026.00	715.39	147.54
Blended	128	18581.50	18752.00	715.39	145.17
Wilcoxon Two-Sample Test Statistic				18581.50	
Normal Approximation					
Z				-0.2376	
One-Sided $Pr < Z$				0.4061	
Two-Sided $Pr > Z $				0.8122	

Table 7. Wilcoxon, Mann-Whitney U (Rank Sums) for Final Course Grade.

Group	N	Sum of Scores	Exp. Under H_0	SD	Mean Score
F2F	164	24858.50	24026.00	714.41	151.58
Blended	128	17919.50	18752.00	714.41	140.00
Wilcoxon Two-Sample Test Statistic				17919.50	
Normal Approximation					
Z				-1.1646	
One-Sided $Pr < Z$				0.1221	
Two-Sided $Pr > Z $				0.2442	

There was a significant difference between the midterm mean for the face-to-face sections and the midterm mean for the blended learning sections ($W=16561.50$, $Z=-3.06$, $p=0.0024$). There was no significant differences between means for the final exam or the final course grades for the two groups ($W=18581.50$, $Z=-0.2376$, $p=0.8122$ and $W=17919.50$, $Z=-1.1646$, $p=0.2442$, respectively).

Since course content was not part of a learning or course management system in previous semesters, accurate data on how much students were accessing the online materials was difficult to collect. Using Moodle allowed faculty to examine when and how much students accessed online content. Preliminary data indicate that the average number of Moodle links clicked by students within the GC120 course site was 417 over 16 week semester (minimum of 61 and maximum of 1111). Table 8 displays the number of hits on the twelve lesson pages.

Table 8. Number of Hits on GC120 Lesson Pages.

Lesson	Hits
Lesson 1 – Introduction to Graphics Communication	710
Lesson 2 – Sketching and Text	429
Lesson 3 – Engineering Geometry	378
Lesson 4 – Projection Theory	393
Lesson 5 – Evaluating 2D & 3D Form: Cylinders & Holes	321
Lesson 6 – Evaluating 2D & 3D Form: Intersections of Surfaces	173
Lesson 7 – Evaluating 2D & 3D Form: Castings & Plastics	270
Lesson 8 – Dimensioning	262
Lesson 9 – Auxiliary Views	241
Lesson 10 – Sectional Views	187
Lesson 11 – Working Drawings & Assemblies	133
Lesson 12 – The Engineering Design Process	93

IV. Discussion

Although students in the blended learning sections performed just as well as students in the face-to-face sections on the final exam and in the course, the mean score for the midterm exam was significantly lower between the groups. This is not consistent with a previous study. During the Fall 2008 semester there was no significant difference between the blended learning sections (85.10) and the face-to-face sections (85.66) on the midterm exam, but there was a significant difference between the groups for the final exam (blended mean: 86.30, face-to-face mean: 80.19). These inconsistencies might be explained by differences in the students enrolled or by the faculty teaching the course. The introduction of Moodle might also account for some of the differences. As part of the redesign of GC120, the distance education group on campus (DELTA) provided a staff member to help evaluate some of the changes to the course. This person conducted post-course interviews with students and faculty. Regarding the blended learning structure of the course, some students stated they preferred two

traditional class meetings per week to balance assignments and due dates with other classes. Some students attributed missing assignments and quizzes to the blended structure. Some claimed it was stressful remembering what was due in class and what to submit online. They found the structure of the course website confusing, which made it difficult to find course material. The blended course was perceived as being more difficult with an increased workload.

Faculty noted that there was a steep learning curve for students new to logging in and using Moodle. Students had many questions about the structure of the course website at the beginning of the semester. One instructor stated that it took the students the entire semester to get comfortable with Moodle. As the semester progressed, students had fewer questions about how to use the website and online materials. Students also visited the site less frequently toward the end of the academic term and relied mostly on their textbook to prepare for exams.

V. Conclusions

The results from this study are somewhat mixed compared with previous studies. Although the mean score on the midterm exam was lower for students in the blended learning sections, it was still at an acceptable level (86.59). Final exam and final course grades were consistent with those for the face-to-face sections.

Since this was the first semester Moodle was used to host all course content, faculty expected some changes would need to be made to both the structure and content of the online material. Post-course interviews with students and faculty confirmed some of the problems that were occurring during the semester.

VI. Future Work

For the Fall 2009 semester course content for within Moodle will be revised per the feedback gained from faculty and students. In addition to Moodle, faculty will be using two other methods to improve student learning. Interviews with students during the 2009 Spring semester revealed problems with timely feedback with questions on Solidworks assignments. Online SolidWorks help sessions will be scheduled using Elluminate to give students an opportunity to ask specific questions about an assignment without having to come to campus. Another addition to the course will be an automated SolidWorks grader similar to what has been done at Rensselaer Polytechnic Institute (Baxter, 2003; Baxter & Guerci, 2003). Not only will this system give students more control of their learning, it will reduce the amount of time faculty will need to spend evaluating student work.

VII. References

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