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Flipping the Classroom to Engage Students in a Graphical Communications Course

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Abstract

The flipped classroom is not a new concept. It requires students to study concepts before the class, apply what they learn in the classroom, and work with other students, which then makes it possible to get immediate feedback from the instructor. However, the effectiveness of the online study and student's perception of the flipped classroom were not widely investigated in the area of engineering graphics. This paper presents a pilot study of the flipped classroom in a Graphical Communications course. Students are required to study course material online before the face-to-face classroom experience. The online course study includes multimedia materials and an online quiz that they are required to take. The results of anonymous student surveys and exam scores verify that flipped classroom is effective when used for teaching graphics and is well accepted by students.

Introduction

Both the American Society for Engineering Education (Jamieson & Lohmann, 2009) and the National Academy of Engineers (2005) have called for education reform that focuses on developing engineering graduates that are self-learners and problem-solvers. The idea of the flipped classroom is to train students to be self-learners, to study concepts before the class, and to dedicate more classroom time to learner-centered activities so that immediate feedback and assistance can be provided to the students (Vygotsky, 1978; Foot & Howe, 1998; Lage & Platt, 2000). A flipped class is different to an online class because it still involves face-to-face class time with the instructor and it emphasizes interactive group learning activities during the class time (Branoff & Kelly, 2009; Bishop & Verleger, 2013). Especially in today's world, it offers students computer-based individual instruction and requires them to finish closed-ended quizzes and exercises online (Bishop, 2013). Instructors will clarify and reinforce the misconceptions in the class based on the online assessment that is collected (Lage, Platt & Treglia, 2000; Bishop & Verleger, 2013). A pilot study of flipped classroom was conducted in a Graphical Communications course at a private institution in the southeast. Five topics, which include lines and scales, normal surface, inclined surface, oblique surface, dimensions, were chosen to be flipped so that more class time could be dedicated to the clarification of misconceptions, team exercises, hands-on activities, and homework completion. The

objective of the study was to incorporate the flipped classroom to part of the course to examine the effectiveness on teaching and student learning.

Course Structure

The Graphical Communications course was designed to familiarize the students with the basic principles of drafting and engineering drawing, to improve three dimensional (3D) visualization skills, and to teach the fundamentals of a computer aided design. The class met twice a week in the laboratory during this three-credit-hour semester-long course with each class lasting one hour and forty-five minutes. Online materials and quizzes were available to students about three days before each face-to-face class. The materials were used to explain the concepts and include both audio or video recorded lectures, power point slides, and numerous examples. After each online study, there was a formal assessment which consisted of five tiered multiple-choice questions. Students were allowed to take the quiz up to two times and the better score was included in their weighted grades. The quiz needed to be completed no later than the midnight before the class so that the instructor could catch common mistakes and clarify the misconceptions in the class. Classes were always interactive and focused on questions and answers, the team exercises, hands-on activities, and homework completion. A screenshot of the online study of lines and scales, and a screenshot of the online study of auxiliary view are shown in Figure 1 and Figure 2 respectively.

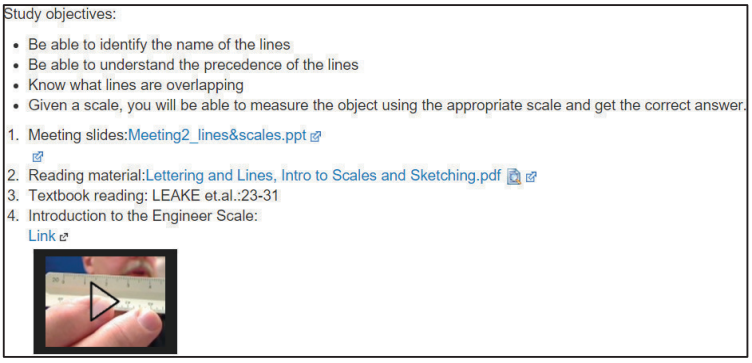

Figure 1. Online study of lines and scales

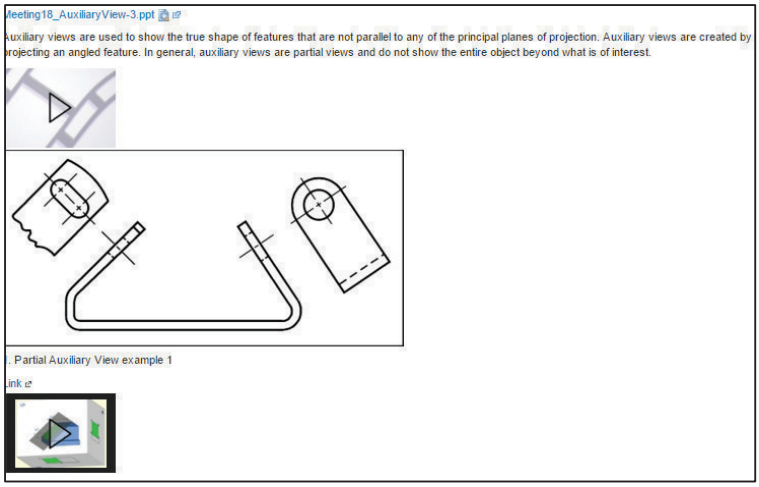

Figure 2. Online study of auxiliary view

An online quiz of lines is shown in Figure 3. An online quiz of auxiliary view is shown in Figure 4.

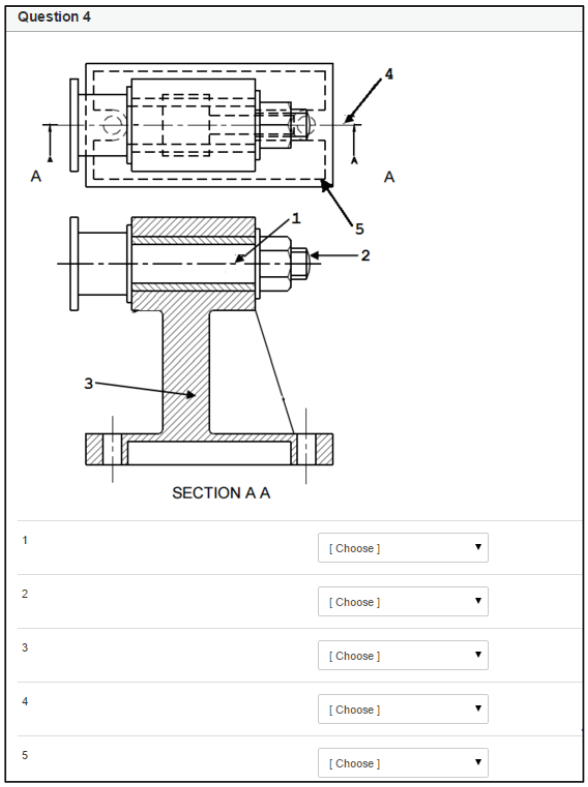

Figure 3. Online quiz of lines

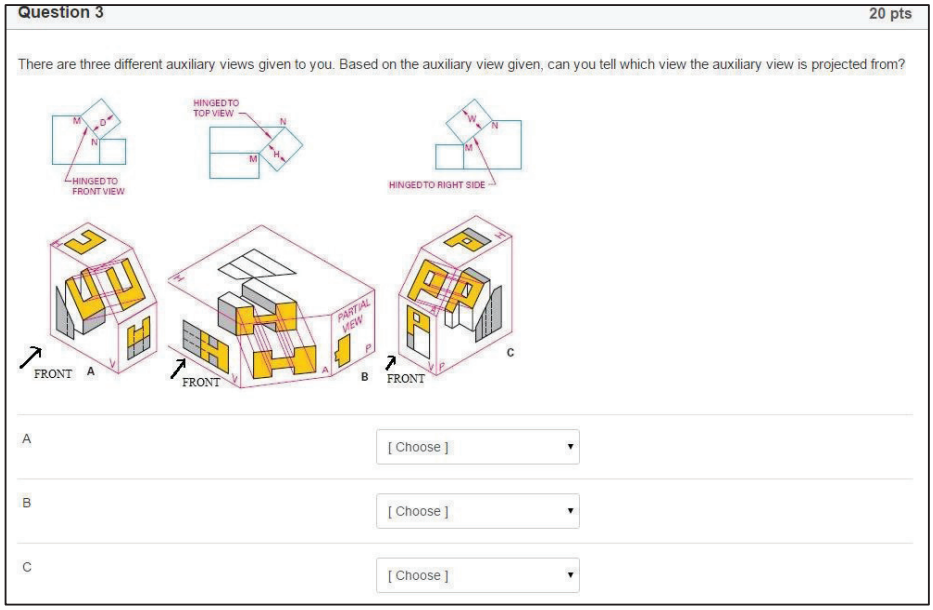

Figure 4. Online quiz of auxiliary view

Assessment

The data from eight online quizzes were collected. A comparison of student's quiz completion rate, second attempt completion rate and performance is shown in Figure 5. Over 77% students typically finished each quiz and their average scores were all above 71 (out of 100). Dimensioning was one of the most difficult topics in this pilot study. It turned out that students' quiz completion rate and performance on dimensioning study were worse than the other topics investigated here. More students tried second attempt to correct the mistakes and achieve higher scores on dimensioning study.

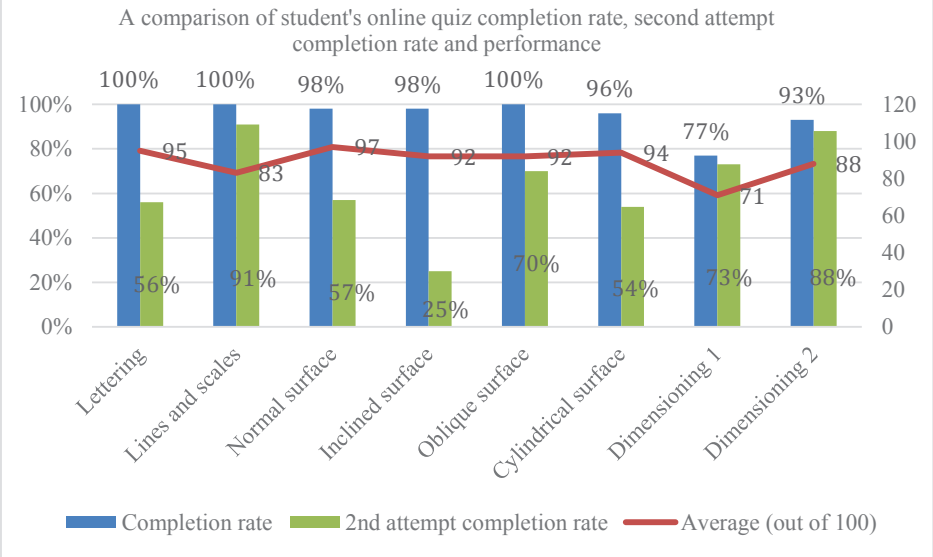

Figure 5. A comparison of student's quiz completion rate, 2nd attempt completion rate and performance

Since the non-flipped class offered in spring 2015 and flipped class offered in fall 2015 were taught by the same instructor and covered the same topics, it provided an opportunity to evaluate the effectiveness of the flipped classroom on student learning. The identical quizzes and exams were given in these two semesters and were graded by the same instructor using the same rubric. The data were collected and compared in Figure 6. Overall flipped class grades were higher than the non-flipped class except for the first quiz. Since this quiz covered easier topics such as lines and lettering when compared to other engineering graphics topics in the flipped classroom study, it was difficult to evaluate the effectiveness of the flipped classroom. As more difficult topics were covered as the semester went, the flipped class grades were much higher than the non-flipped class grades, which probably due to substantially more practice online and in the class time. Flipped class improved student's learning effectiveness.

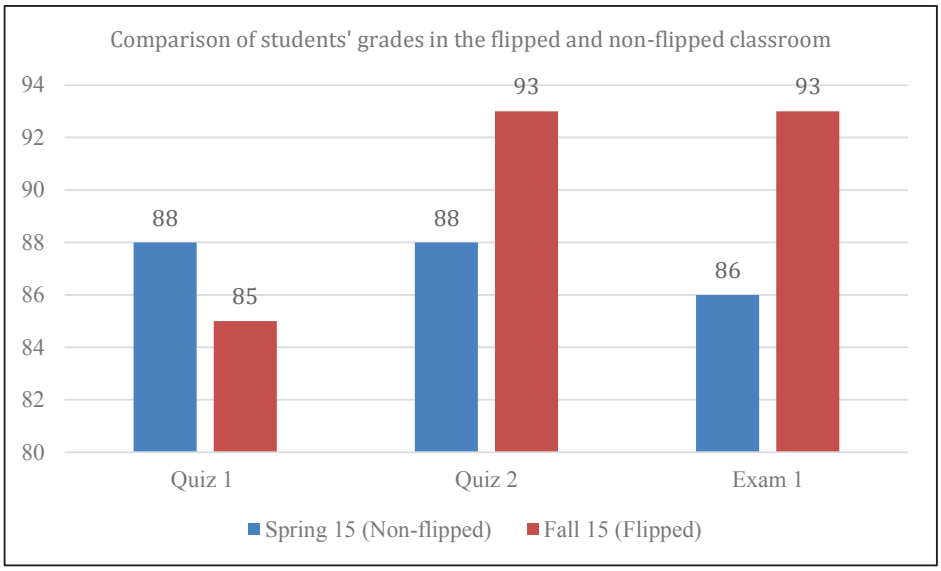

Figure 6. Comparison of students' grade between flipped (n=44) and non-flipped classes (n=55)

To understand students' perceptions of the flipped classroom, an anonymous midterm survey was administered by Center for Teaching and Learning Excellence (CTLE) at the institution. Eighty two percent students (44 out of 54) in two sections of Graphical Communications course completed the survey. Figure 7 indicates that about 80% students are in favor of the flipped class format. Over 63% students spent one hour or more on each online study as shown in Figure 8. Figure 9 illustrates that about two-thirds students would like to continue in the flipped classroom format for the remainder of the semester. *Do they prefer the flipped format if they had to take the course again?* The students' responses were split as shown in Figure 10, although they did not know about the impact on their grades at this time. The flipped classroom approach shows certain positive effects on students' learning, but it needs continuous improvements as is common with all classroom experiences. Modifications such as interactive screencasts, more exercise problems, and online discussion are needed to maximize the advantages of the flipped classroom so that more students can accept it and take advantage of it.

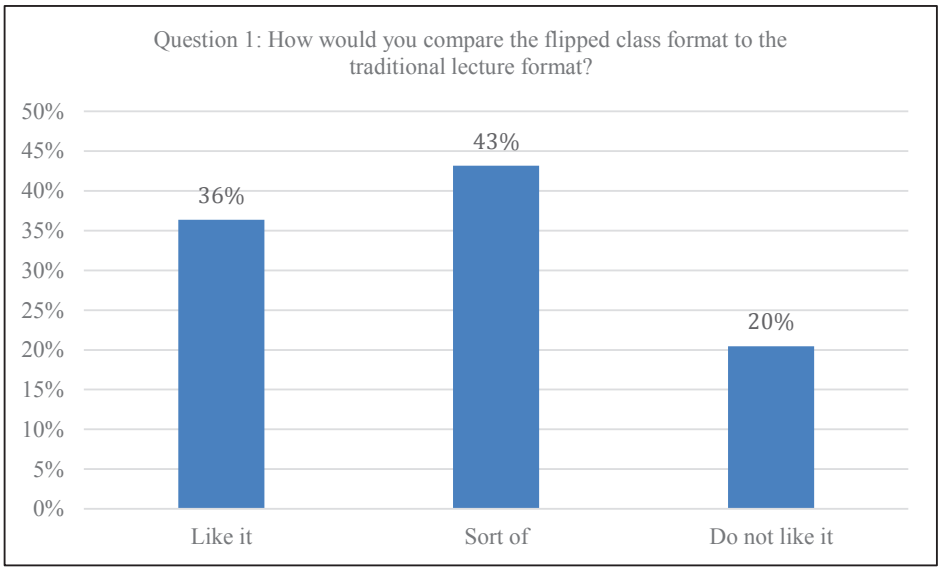

Figure 7. Survey question 1 responses

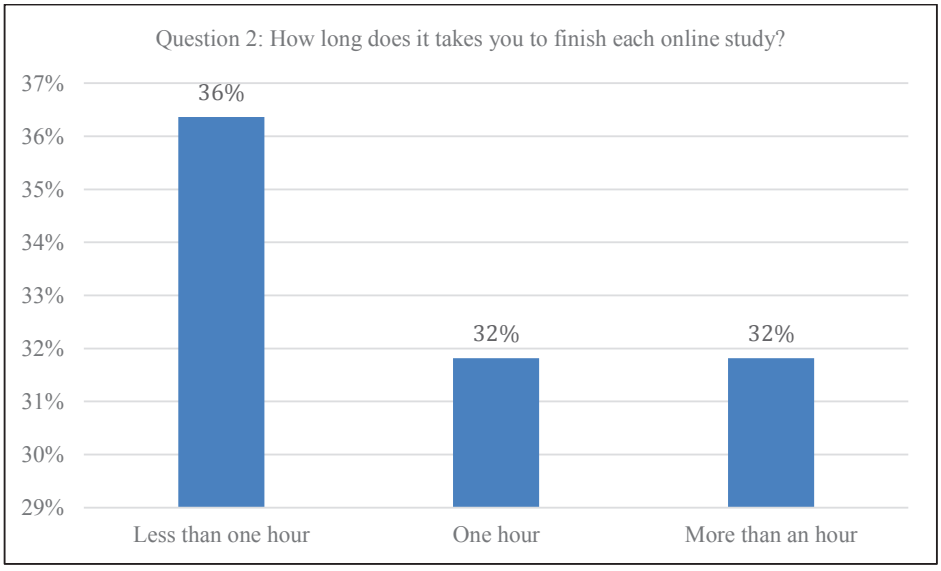

Figure 8. Survey question 2 responses

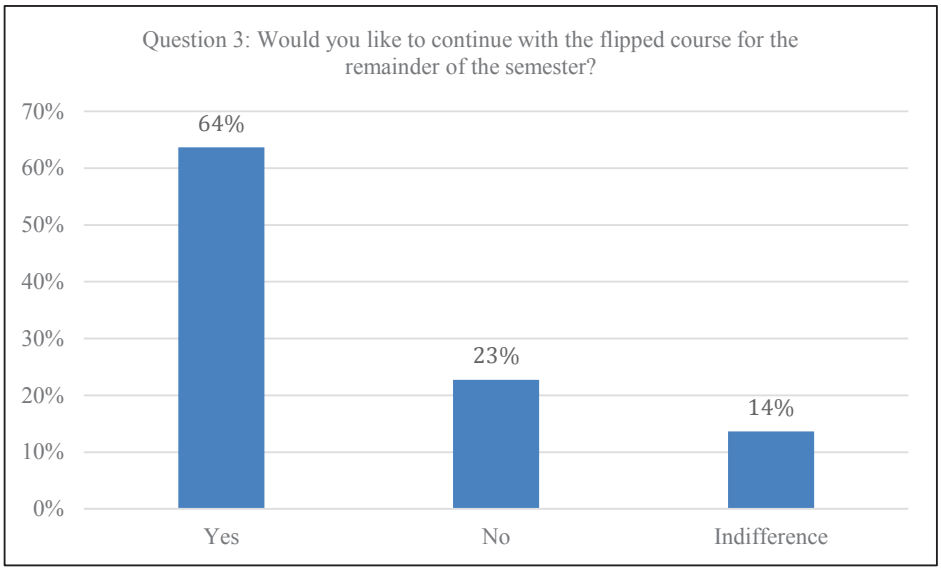

Figure 9. Survey question 3 responses

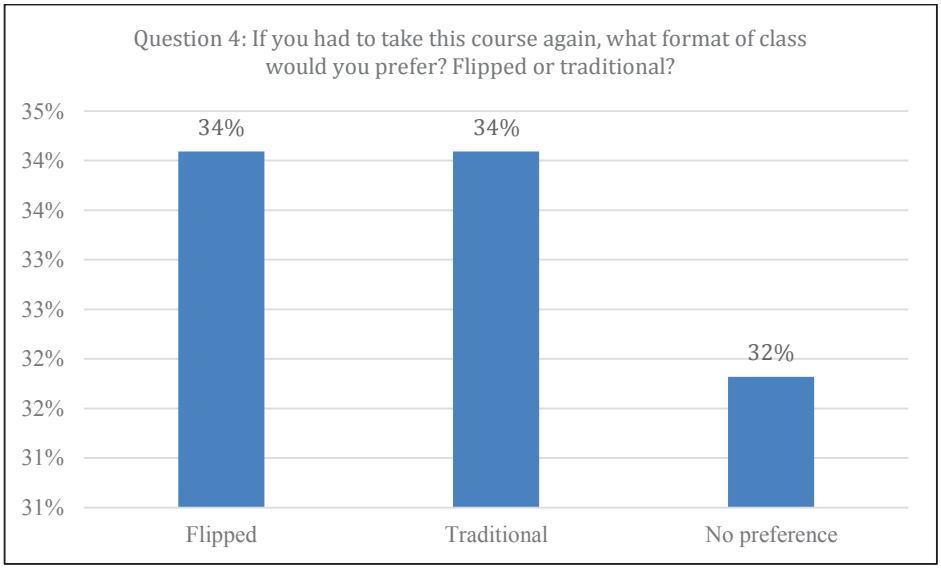

Figure 10. Survey question 4 responses

The following are comments from students regarding the flipped classroom approach (not corrected for grammatical errors or spelling mistakes).

- *The online resources like powerpoints and whatever help because we usually look over it at home before doing it in class, so we kinda get a preview and that helps.*
- *By going over examples and then being able to start the homework in class. We can watch her do examples and do them on our own as well. The study material being posted online was very helpful.*

- *The attention to detail; online study guides/power point presentations; the in class examples. The two chances to take the online quizzes at the beginning of the course was very helpful.*
- *This course is partly depending on practice and out of class learning, which has allowed me to develop autodidactic skills. However, Professor Sun is very proficient in explaining things that we might find difficult to understand. For example, lettering was something that we had to learn ourselves, but it just required practice. On the other hand, she made us learn line types but helped us understand the difficult subjects concerning their use.*

Conclusions

A pilot study of the flipped classroom in the Graphical Communications course was conducted in the early part of the fall 2015 semester. Student's quiz completion rate, second attempt completion rate, and performance were collected and compared. When the topics got harder such as scales and dimensioning, the second attempt completion rate increased. Students' grades were compared with those from spring 2015. Students' scores increased dramatically through the comparison of the quizzes and exam over the two semesters. A midterm survey was administered to understand student's perception. An anonymous student survey found that most students viewed the flipped approach favorably, and two-thirds would like to continue in that format. The results of quiz and exam scores verify that flipped classroom is effective. In summary, the flipped classroom approach shows many positive impact on students' learning and achievement, but it needs continuous improvement based on student input.

Acknowledgment

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