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WIP: Student Outcomes From Rapidly Flipping a Large-Scale Biomedical Electronics Course

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WIP: Student Outcomes from rapidly flipping a large-scale biomedical electronics course

Background & Goals

Although there has been a steady growth of student-centered teaching practices, prior to Covid-19 global pandemic many university professors still favored a teacher-centered learning environment. While professors would occasionally have "clicker questions" to check for understanding during the class time, most courses were widely devoted to transcribing notes. The rapid transition to online learning formats permitted a seismic shift to more student-centered learning approaches. Our undergraduate Biomedical Electronics course already recognized the need to transition to a flipped classroom model to enhance learning and was in the middle of a 4-year transition. The Covid-19 pandemic decreased the period for this transition to 2.5 years.

Rapid conversion of courses is an un/fortunate side effect that the Covid-19 global pandemic had on academia. Zoom based dialogue, instruction, and teaching became necessity. [1] While each degree program and course comes with challenges, biomedical engineering laboratories and courses have their own due to the varied natures of biomedical engineering curriculums. [2] Biomedical engineering laboratories have challenges as discussed by Lancashire et al. [3] The general consensus among faculty at Texas A&M Biomedical Engineering was to simply "live Zoom teach" for the traditional 3-credit hour courses. Biomedical Electronics, a 3-credit hour junior level course, was already progressing toward a flip-classroom model on a 4-year timeline. The goal of this project is to determine if transition to a flipped learning model classroom and rearrangement of course materials would improve student learning outcomes in a biomedical electronics course.

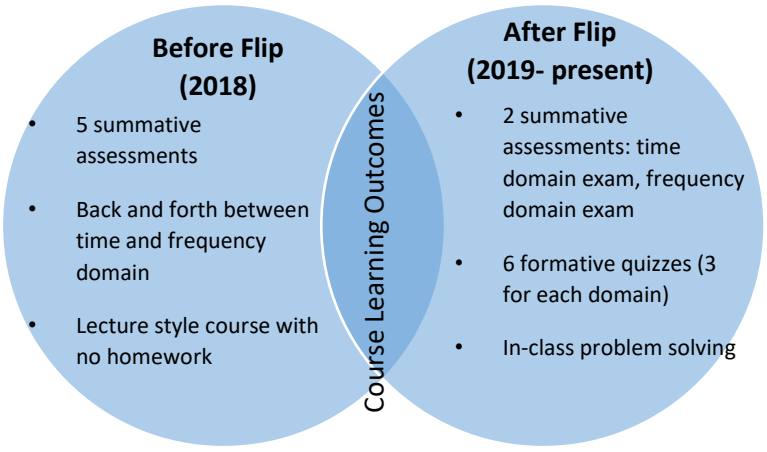

Figure 1. Venn diagram comparing two methods of teaching circuits course.

Research Approach

Biomedical Electronics is a 3rd year undergraduate course taken after completion of differential equations and a signals and systems course. In academic year (AY) 2018-2019 and prior, the biomedical electronics course was taught in a traditional format with two sections of approximately 80 students and 5 summative assessments. There was a recognized need for re-arrangement of course content into distinct time-domain and frequency-domain sections rather than an intermingling. In AY2019-20, the course was altered to four sections with two summative assessments (exams) and five formative assessments (quizzes). During this rearrangement, the teaching days switched from three days a week to two days a week. Subsequently, the instructor gradually introduced more student-centered learning by only instructing one day and providing challenge problems on the second day of each week.

Additionally, the summative assessments were grouped to correlate with adaptation of content delivery: a time-domain exam and a frequency domain exam.

During the AY20-21, due to Covid-19 limitations on in-person student numbers, the instructor further shifted towards a flipped classroom model. Recorded lectures provided the main content while "in class" days via Zoom focused on working out problems. The instructor presented a problem at the same difficulty level of quizzes and exam, allowed students to work individually or in groups for approx. 10-15 minutes, and then reconvened. Guiding questions were asked to solve the problem. It is hypothesized that the student learning outcomes will increase compared to a traditional lecture style learning environment as also demonstrated by Lee [4]. Mitigating factors may include differences in testing environments (at home vs in live-proctored), move to online "in class days", and inability of the instructor to "read student faces" to assess their level of learning. Figure 1 describes major differences after the flip initiation.

A three-year statistical analysis of retrospective student grade analysis was conducted (IRB# 2021-0058M). ABET Outcome 1 of Criterion 3, the assigned ABET outcome for this Biomedical Electronics Course, was further defined and evaluated as the following sub-outcomes:

A. Ability to identify and formulate a circuit solution in time domain.
B. Ability to identify and formulate a circuit solution (find the transfer function) in frequency domain.
C. Ability to interpret the transfer function of a circuit.
D. Solve complex engineering problems applying either Kirchhoff's Voltage Law (KVL) circuit theory or Kirchhoff's Current Law (KCL) in time domain.
E. Solve complex engineering problems applying either Kirchhoff's Voltage Law (KVL) circuit theory or Kirchhoff's Current Law (KCL) in frequency domain.
F. Calculate voltage outputs from circuits containing operational amplifiers.
G. Identify and formulate solutions to filter and amplify biosignals using principles of engineering.

Outcomes were assessed through either a quiz or a test question depending on the semester the course was offered. To evaluate the effectiveness of the flipped classroom model and inclusion of student-centered teaching techniques, it is hypothesized that upon inclusion of the flipped classroom activities, a greater percentage of the class population will pass the ABET outcome 1 sub-outcomes. Data was collected describing the year, the number of students, the number of assignments per sub-outcome, and the total number, N, used for statistical analysis. Graphpad Prism was used to complete a one-way ANOVA testing with post-hoc Dunnett test. Fa18 was used as the control group since the course was taught in traditional lecture style. Significance was assigned at a p-vlaue of < 0.05. Additionally, students completing the course in fall 2020 were invited to fill out a 21 question qualtrics poll (IRB# 2020-1142M). Twenty-four ($N = 25$) students responded. The comments were analyzed and some presented in the results section. No control group was used for student questions.

Results and Analysis

The transition to a flipped classroom model was successful from a necessitated shorten time-line perspective. All the materials were fully deployed during the Fa 2020 semester, an entire year prior to projected timeline. Preliminary analysis (Figure 2) suggests that the accelerated timeline to flip an undergraduate biomedical electronics course is partially effective. Sub-outcome E was not assessed due to no clear problem being assigned during the Fa 2018 semester (control group). Sub-outcomes A and G had no change throughout the flip. Sub-outcomes B and F were statistically significantly increased ($p < 0.05$) due to the flip; while sub-outcomes C and D significantly decreased ($p < 0.5$) compared to the 2018 semester. In-short, it is a mixed bag to the effectiveness of the flip. Further, assessment type and questions changed. For the control year (2018), all assessments were summative. Since 2019 assessments have been a mix of summative and formative (that are still for a grade). Additionally questions are changed yearly though the concepts covered remain the same; regardless, this could influence the data.

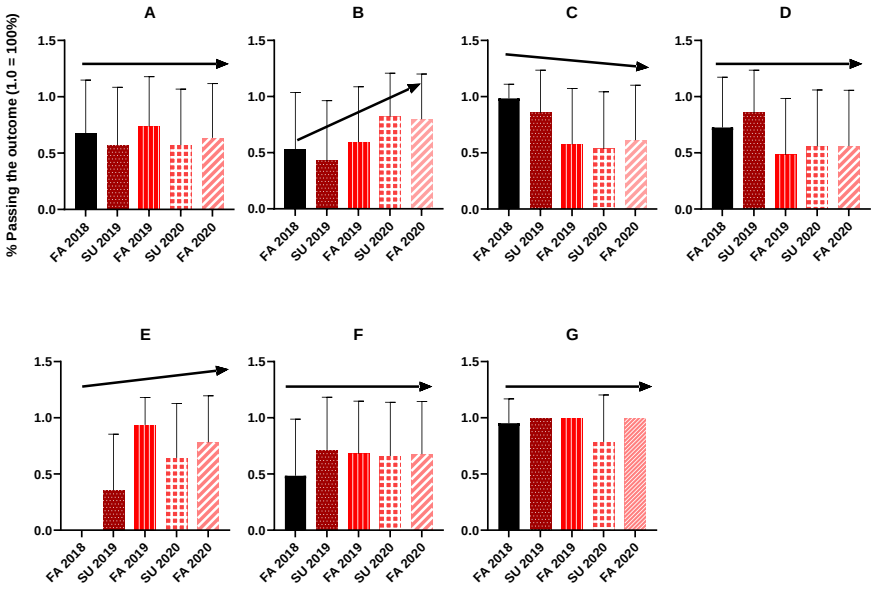

Figure 2. Summary of Data used for statistical analysis. Trends indicated by the arrow direction (up, flat, or down).

In examining students' comments are mixed as well, "The idea of a flipped classroom is overall beneficial to the learning environment of both the students and the professor. However, during current times of the pandemic having the classes do a flipped classroom setting prevents the interaction aspect that students are already missing." "I generally liked the lecture on your own time and application style work during class. I feel as it is more helpful than using class time for lectures." Further analysis of how students feel revealed that 72% (N = 25) answered neutral to positive to the question, "I was focused and engaged with video lectures." Based on a five-point Likert scale. 88% of student respondents were neutral to positive in "Video lectures helped me learn the material." And 60% were neutral to supportive of "I was satisfied with the flipped classroom system."

Conclusions

From these data and the mitigating circumstances (Covid-19) it is too early to determine through quantitative measures with significance if a flipped classroom approach is effective in a Biomedical Electronics course. However, student viewpoints are generally favorable and support the continued approach. Further data analysis will occur to determine how to further improve the course and the outcomes therein.

[1] S. Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis," (in eng), *Journal of Educational Technology Systems*, p. 0047239520934018, 2020, doi: 10.1177/0047239520934018.

[2] J. A. White *et al.*, "Core Competencies for Undergraduates in Bioengineering and Biomedical Engineering: Findings, Consequences, and Recommendations," *Annals of Biomedical Engineering*, vol. 48, no. 3, pp. 905-912, 2020/03/01 2020, doi: 10.1007/s10439-020-02468-2.

[3] H. Lancashire and A. Vanhoestenberghe, "Rapid Conversion of a Biomedical Engineering Laboratory from in Person to Online," *Biomedical Engineering Education*, vol. 1, no. 1, pp. 181-186, 2021/01/01 2021, doi: 10.1007/s43683-020-00031-y.

[4] A. Z. Lee, H; Middleton, J, "Effectiveness of flipped classroom for mechanics of materials," presented at the American Society for Engineering Educations, New Orleans, LA, Jun 26 2016, 2016, Paper ID #15734. [Online]. Available: SCOPUS:84983314217.