WIP: Student and Faculty Experience with Blended Learning in a First-Year Chemistry for Engineers Course

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1. Introduction

Chemistry for Engineers is an introductory chemistry course taken by most engineering students at our university during their first term. As such, student background knowledge, readiness for university and interest in the subject matter is varied. Over the past two years the course has been moved to a blended learning mode in order to: i) create time for more valuable instructor–student interactions, allowing the instructor to reinforce challenging concepts, focus on problem-solving strategies and lead experiential learning activities, and, ii) allow students to explore content at their own pace, thereby accommodating the diversity of students' high-school preparation. Our study aims to compare and contrast student experience, satisfaction and performance between a blended and traditional model of instruction through data from surveys and grades. The blended format was piloted during Fall 2016 for half of the course content in a few sections [1]. In Fall 2017, the course was offered in a fully blended mode for the first time.

2. Course Design for Fall 2017

The course was offered in either blended or traditional format, based on instructor preference. In the traditional format students attended three hours a week of lecture. In the blended format access to online modules replaced lecture content, and the instructor focused on reviewing key concepts and problem solving during class. The online modules, developed by the course instructors, incorporate media, such as: narrated slides, animations, simulations, videos, solved example problems and concept check questions with adaptive feedback. In an effort to maintain a consistent work load, class time was intended to reduce to two hours per week for the blended students, allowing one hour for self-study online. Due to scheduling constraints, regular classroom time was revised to 1.5 hour with an additional 1.5 hour as a classroom-based office hour. Both modes included two-hour tutorials structured as group problem-solving sessions led by a graduate student teaching assistant. For the blended sections, two of these sessions included a hands-on experiential learning activity run by the course instructor. All students received the same tutorial problems, assignments, midterm exam and final exam.

From the pilot study, it was apparent that some students expected "to be taught" in a traditional classroom setting, rather than seeing the course as an environment for them to learn. In an effort to generate student buy-in, motivation for the blended format was introduced using the first-day of class questions suggested by Smith [2]. Care was taken to explicitly establish clear expectations around both what the students should be doing and when they should be doing it. A webpage laid out the sections of the online content that should be completed in preparation for each class, as well as guiding questions for students to consider as they studied. Unfortunately, it was not possible to track the extent to which students engaged with the content. Students were required (via a participation grade) to submit responses to reflection questions prior to class asking them to identify: i) the main concepts covered, and, ii) any specific questions they would like addressed in class. Understanding of concepts covered online was assessed in class using iClickers, with the remainder of class-time focusing on problem solving.

3. Study Design

Total enrolment for the course was approximately 1400 students in twelve lecture sections ranging in size from 80–160 students, depending on program. Based on instructor preference, the students were taught using either a blended learning model or a traditional model. Four instructors, teaching five sections, used a blended learning model (identified as B1–B5); five instructors taught the remaining seven sections using the traditional model (T1–T5; two sections not included based on the instructor's request to not participate in the study). One instructor taught one section in each mode to students of the same program, providing two similar groups for comparison (B3 and T5). Historically there have been persistent differences in class averages based on engineering discipline (and regardless of instructor); sections B2 and B4 have typically had significantly lower class averages and section B5 (the only section of second-year students) significantly higher.

Throughout the term, three surveys were administered. The first was given after the first day of class in an effort to assess preconceived ideas about the course and initial reactions to the proposed class format. The second and third surveys were administered the week before the midterm exam and the final week of class, respectively. Questions on these surveys were phrased to address the following research questions:

1) Does the changed course format affect student reaction and experience?
2) Does the delivery method affect student confidence and self-efficacy?
3) Does the delivery method affect perceived effectiveness of content delivery?
4) Does the delivery method alter the perceived relevance and value of the course?

Additionally, survey results were combined with course grade data to assess whether the changed course format affected student learning.

4. Results and Discussion

4.1 Implementation and Demographics.

The beginning and end-of-term surveys asked about the relevance of this course to their engineering education. Initially, students across all sections overwhelmingly agreed or somewhat agreed that this was true, with the exception of the second-year students in B5. By the end of term, the responses varied greatly by discipline (Figure 1). Comparing B3 and T5, perceived relevance and mode of instruction do not appear to be associated. The perceived relevance of the course may have impacted the time students spent on this particular course and their willingness to engage with the course content, discussed below.

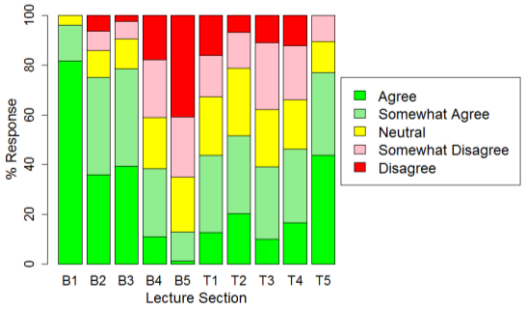

Figure 1: Response to the end of term survey question, "This course is relevant to my engineering education." A χ^2 contingency test comparing the response for B3 and T5, fails to reject the null hypothesis that there is no association between survey response and mode of instruction.

Throughout the term instructors teaching B2 and B4 deviated from the intended model and increased the amount of in-class time based on perceived student understanding of course content. Instructors of the remaining sections found that 1.5 hour per week was somewhat rushed, but adhered to the intended schedule, sometimes posting supplemental information online. When asked how much time on average they spent on the course, students in B2 reported a significant increase compared to other sections; this is consistent with the additional in-class time scheduled by their instructor. For students in B3 and T5 the time spent on the course was

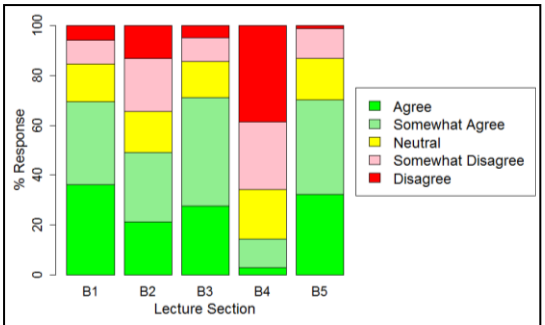

Figure 2: Response to the survey question, "The delivery of this course, through online material, in-class activities and tutorials, met my expectations of a university course."

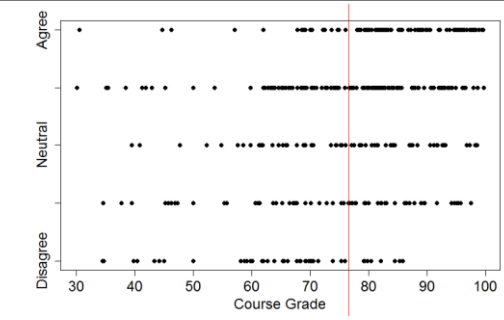

Figure 3: Response to the survey question, "The delivery of this course, through online material, in-class activities and tutorials, met my expectations of a university course" vs. course grade. The red line shows the mean course grade for students who responded to this question.

comparable, regardless of the mode of instruction.

4.2 Student Performance. An overall comparison of blended vs. traditional student final course grade reveals no meaningful difference. Comparing B3 and T5, there was no significant difference in course grade based on mode of instruction. There are historically persistent differences in course grade depending on lecture section; this pattern was not affected by the introduction of the blended learning model, with the exception of B2. B2 and T1 contain students in related disciplines with similar admissions averages. Despite these similarities, the final course average has historically been significantly lower for B2 (in 2016, 60% vs 67%, both groups taught using the traditional model); for this offering, the course averages were 71% compared to 70%. We are investigating whether this improvement may be related to the mode of instruction or whether there is evidence that this particular cohort is relatively stronger.

4.3 Student Satisfaction. At the end of the term, the majority of students (57%) receiving the blended model of instruction, responded positively when asked if the course format met their expectation of a university course (Figure 2). However, students in B4 overwhelmingly (66%) disagreed with this statement. Owston and colleagues determined that high-achieving students have a preference for, and fare better in, blended learning courses than their lower-achieving counterparts [3]. While in principle all students accepted into engineering at our university fall into the high-achieving category, there remain substantial differences in admission averages. Students with above average course grades were more likely to agree with the statement that the method of course delivery met their expectations than those with below average course grade (Figure 3).

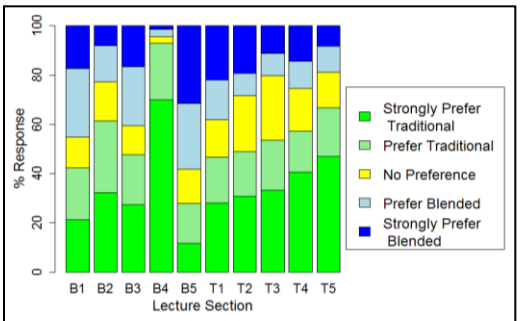

Figure 4: Response to survey question, "Based on your experience which of the following modes of instruction should we implement for future offerings of the course."

During our pilot study there was strong resistance towards the blended model. At the end of term students were asked which mode of instruction we should implement for future offerings; of those students who experienced the blended pilot, only 12% indicated blended, with 74% traditional and 14% no preference. This term the responses were much more positive (Figure 4) with students in B1–5 indicating 55% traditional, 33% blended and 12% no preference. There was significant variation depending on lecture section,

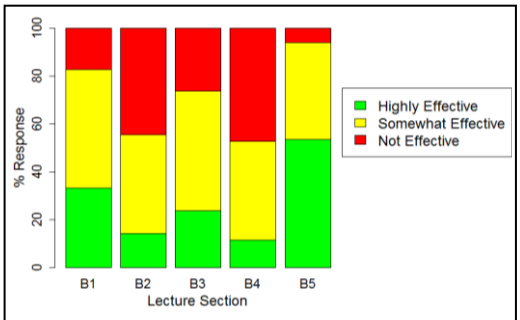

Figure 5: Response to the survey question, "To what extent were the following course activities effective in helping you learn? –Online material."

with responses ranging as high as 58% preferring blended (B5) to only 4.3% preferring blended (B4). Interestingly, students exposed only to the traditional model showed substantial interest in the blended model, with 51% indicating traditional, 29% blended and 20% no preference.

4.4 Student Perceived Effectiveness. A series of questions asked students to rate whether they found different aspects of the course to be highly effective, somewhat effective or not effective. The perceived effectiveness of the online content was associated with lecture section enrollment. A higher fraction of students in sections with lower course averages (B2 and B4), found online content not effective for learning (Figure 5).

4.5 Instructor Experience. At the end of term, the course instructors using the blended model were interviewed. Overall the instructors were positive regarding the blended model and are keen to implement it again, but agree that some changes need to be made. First, it was clear that the scheduling-driven change to 1.5 hour classes gave insufficient contact time. Second, it was identified that the amount of content was excessive in some modules. Third, use of the reflection questions was challenging due to the fast turnaround (sometimes overnight) between student submission and the next class. The instructors for B1, B3 and B5 reviewed the questions in detail and made an effort to answer each question either in class or through online responses. The instructor for B2 reviewed the responses and used these to determine which concepts to address in class. The instructor for B4 admitted not having time to look at responses before class.

5. Conclusions and Future Work

Our preliminary analysis seems to show no significant difference in student performance, but data analysis is ongoing (due to ethics considerations the data were only recently released for analysis). A major weakness of the blended model is the capacity of students for self-directed learning and so we have identified a need for the course to address metacognitive outcomes – in essence, the course needs to provide support to help students "learn how to learn". Some students stated that they could not learn using online content and "needed to be taught," as if this is an inherent fact rather than a skill that can be developed. In particular, sections who traditionally struggle with this course did not find the online content effective for learning and were less satisfied with the blended model. Future course offerings may include a specific study skills outcome. This would be beneficial for first-year students as they transition to university and would also help develop life-long learning skills. We also intend to develop a workbook to accompany the online content as a scaffolded study guide, gradually providing less detail as the term progresses.

While outside of the scope of the current study, we hope to revisit the online content in an effort to identify which aspects are beneficial to student learning and which need further improvement. Through partnering with the company that provides the software platform, we hope it will be possible to track student engagement with specific course components.

For instructors considering a blended course model, we note that a course redesign of this nature requires very considerable time and effort; here, this effort was evident both in the design of the online and in-class components of the course. While we made substantial improvements between the 2016 and 2017 offerings, additional work is required to fine tune online content, develop better accompanying resources and successfully integrate the online and in-class learning components. We continue to believe that the blended learning model will eventually lead to better outcomes in this course and intend to continue to pursue our evidence-based approach towards course improvement.

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