Evidence-based Best Practices for First-year Blended Learning Implementation

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Abstract

The objective of this evidence-based study is to synthesize best practices for developing flipped classroom material in large-scale first year courses. These best practices are extracted from three years of flipped classroom implementation experience in both technical and design engineering courses mandatory for first year students. This research will present valuable lessons and analyze differences between the suitability of different course types for the flipped educational model.

Best Practice #1: Implementation of the flipped teaching and learning approach should be associated with three phases. Starting with a pre-classroom phase, followed by an in-class active learning approach, and finally the third stage that allows students to practice a real-world application of the concepts that learned in the two previous stages.

Best Practice #2: An online learning approach should add value to, rather than replace, in-class learning. The varied video types facilitate efficient and effective individual learning, but they do not include collaboration or interactivity. The online material should be used to enable in-class creative problem-solving and applied learning led by an instructor. From a different angle, this also means that flipped classrooms teaching approach should not be chosen as a cost-saving or time-saving option.

Best Practice #3: Flipped classroom instructors should not rely solely on traditional performance assessment of students. One of the advantages of online teaching is the huge size of invaluable data that is collected as students access the provided online learning resources. For example, learning management systems such as Desire2Learn are often used as a platform to provide teaching and learning media. Most learning management systems provide substantial amounts of data regarding student interaction and related use behavior. Mining this data allows us to analyze students' study habits. Although not all available data may show significant statistical correlation with students' study behavior, a data mining approach with the support of additional data collection via questionnaire or surveys can lead to a valuable set of information for improving the curriculum or teaching methods.

This paper will present implementation and feedback findings from multiple flipped offerings of an introductory programming course and a first-year engineering design and communication course. In addition to detailing the best practices above, this study will compare and analyze the impact of flipped material in technical versus design-based courses.

Introduction

Flipped and blended learning models have been implemented in many engineering programs, but there is still conflicting evidence regarding scalability, feasibility, and effectiveness for large-scale courses [Velegol, 2015]. The benefit of implementing these models is that they allow instructors to use their face-to-face time with students for exploratory, hands-on application of material [Kolb, 2005] [Robinson, 2004].

Both ENGG 200 and ENGG 233 are required courses for the first-year common core program at the Schulich School of Engineering, University of Calgary. The most recent enrollment numbers have reached approximately 850 students for each course, which presents unique challenges for effective active learning practices. This evidence-based paper will compare the implementation of the same blended learning tools in both an introductory technical course and an introductory design course.

Implementation Model

ENGG 200 is the first-year design course and is a required course for all students. It introduces students to the engineering design process through the use of multiple team projects and deliverables. ENGG 233 is a required first-year technical course that introduces foundational concepts in programming and software engineering to all students, regardless of their intended program.

In 2015, ENGG 233 was redesigned to focus on algorithmic thinking through exploratory and applied learning, as opposed to syntax-focused programming education [Pears, 2007]. This resulted in a course format similar to ENGG 200.

Both courses have a significant regular laboratory component, where students are given the opportunity to collaborate with peers and receive coaching from instructors and teaching assistants. In these laboratory sessions, students work on exploratory exercises and larger design-based projects. This interactive instruction time provides opportunities for applied learning, creative problem-solving, and personalized feedback [Marasco, 2016].

To facilitate the interactive classroom time, both ENGG 200 and ENGG 233 have moved to a flipped learning model, where domain knowledge concepts are presented ahead of laboratory sessions using online lectures. In ENGG 200, this model is supplemented with occasional lectures from instructors and industry guests. In ENGG 233, this model is supplemented with scheduled tutorial sessions [Marasco, 2017].

Online Learning Methodology

Literature suggests that video lessons should be approximately 10 to 15 minutes in length, and that students may benefit from seeing an instructor’s face rather than hearing only voiceover. After multiple course offerings, the videos used in ENGG 200 and ENGG 233 have been refined to use similar development techniques.

Instructors recorded lectures using a web cam, a high-quality microphone, and screen recording software, which enabled both real-time content integration through a Microsoft Surface tablet and prepared content through PowerPoint slides. Storyline 360 by Articulate was used to integrate PowerPoint slides and recorded video into a complete module. Storyline 360 also facilitates the addition of LMS-compatible assessment and tracking. Another feature allows a limited menu, which prevents students from simply scrolling through module without watching material in its entirety. The videos were released weekly in each course, and required completion within the following week.

The developed videos used in ENGG 200 and ENGG 233 can be organized into four different types. ENGG 200 primarily used Category 1 for material such as phases within the engineering design process, professionalism in engineering design, technical writing, and communication. ENGG 233 delivered regular course concepts through Category 1, with Categories 2-4 being used to further support student learning.

Category 1: Video Lectures

In video lectures, an instructor would introduce and explain course concepts, building on previous videos as the course progressed. To encourage active participation and accountability, students were required to answer short embedded quizzes. The use of this assessment method also provides immediate feedback and motivation. A screenshot showing the format of the video lectures can be seen in Figure 1.

The embedded quizzes were designed in three different formats. ENGG 233 primarily used Format #1, while ENGG 200 used a combination of all three.

Format #1: Every 5-7 minutes (depending on video length), students are presented with a quiz question about the material just presented. When possible, quiz questions are randomly drawn from a quiz bank, reducing issues around possible cheating. Students were able to review the previously watching material before submitting a final answer and moving to the next video segment.

Format #2: After watching the entire video, students were presented with a summative quiz. Students were able to review the video lecture material before submitting a final answer for each question.

Format #3: After watching the entire video, students were required to submit a single completion entry to receive completion marks.

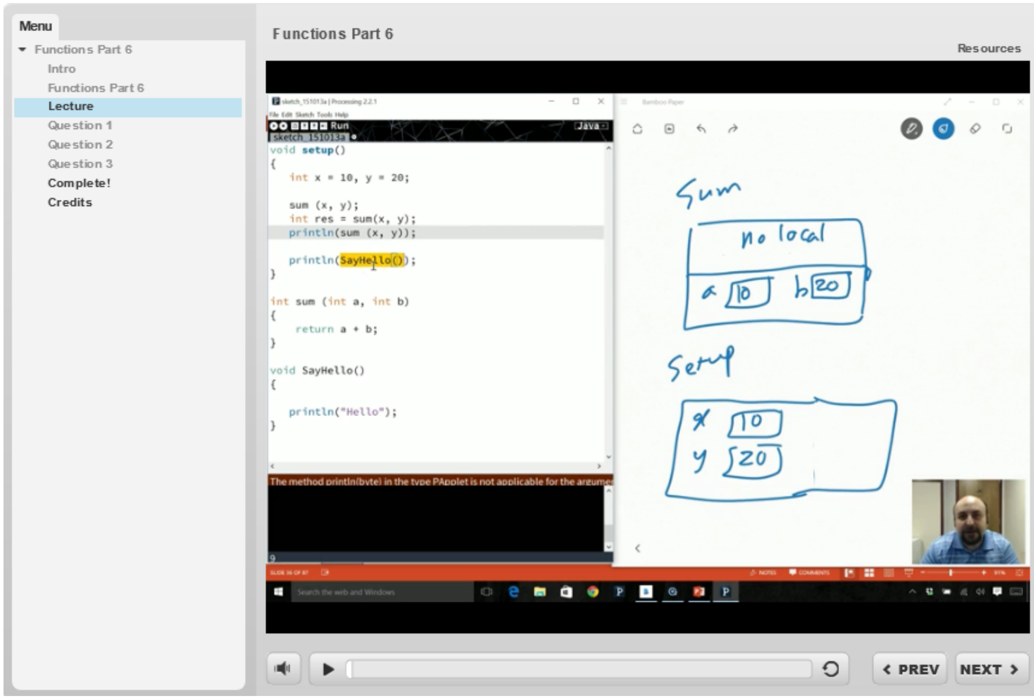

Figure 1. An example screenshot of a Category #1 video lecture module.

Category #2: Video Tutorials

In video tutorials, an instructor would break down examples, further explaining the application of concepts while also demonstrating necessary problem-solving skills. While there was no assessment integrated in this video type, the step-by-step example solutions were a valuable study resource for exam preparation.

Category #3: Just-In-Time Help

Just-in-time help videos require additional instructor time and effort, but are an important part of supported learning. Based on problem areas identified through analyzing work, feedback from teaching assistants, and questions from students, instructors would create additional supplemental lectures to support struggling students through difficult concepts.

Category #4: “What I Struggled With”

The “What I struggled with” video series was created to highlight challenging aspects of the course. This technique is used by other organizations within online learning platforms, such as a popular UCSD Coursera specialization on data structures and algorithms [UC San Diego, 2018]. These videos rely on feedback from past students and previous iterations of the course to identify concepts that may need additional study time.

Course Comparison

Following the conclusion of each course offering, students were asked to provide feedback via a mixed methods survey, which combined quantitative rankings with open-ended qualitative responses. As ENGG 200 and ENGG 233 are both required first-year courses, there is almost complete overlap in the registered cohort, allowing student experiences to be compared. Instructors were also asked to provide feedback on the various types of implementation techniques.

An examination of the two courses led to the discovery of common themes, despite one course focusing on technical engineering material and the other focusing on the engineering design experience. These themes have been organized into three best practices for developing and implementing online learning material.

Best Practice #1: Implementation of the flipped teaching and learning approach should be associated with three phases. Starting with a pre-classroom phase, followed by an in-class active learning approach, and finally the third stage that allows students to practice a real-world application of the concepts that learned in the two previous stages.

To ensure that students are prepared for the in-class active learning, an assessment or accountability method must be used. Overall, instructors observed that students take the videos more seriously in ENGG 233, possibly due to more complex embedded assessments and more difficult learning concepts. The further use of completion quizzes (Format #3) is not recommended by the ENGG 200 teaching team, and future implementations of the course will include a redesign of the online modules to include more meaningful assessment questions. Given the success of a quiz bank for varied and randomized questions in ENGG 233, instructors for ENGG 200 hope to implement a similar system.

Best Practice #2: An online learning approach should add value to, rather than replace, in-class learning. The varied video types facilitate efficient and effective individual learning, but they do not include collaboration or interactivity. The online material should be used to enable in-class creative problem-solving and applied learning led by an instructor. From a different angle, this also means that flipped classrooms teaching approach should not be chosen as a cost-saving or time-saving option.

Students generally perceive the online lectures to be helpful. The most recent 2017 data shows that 80% of the ENGG 233 students agreed or strongly agreed that the online lectures were helpful. This compares well to 79% in 2016, and 73% in 2015. The increasing data trend also suggests that the quality of development and implementation may be improving as well.

Best Practice #3: Flipped classroom instructors should not rely solely on traditional performance assessment of students. One of the advantages of online teaching is the existence of tremendous amounts of data, which is automatically collected as students access the provided online learning resources (videos, slides, external media, etc.). For example, learning management systems such as Desire2Learn (D2L) are often used as a platform to provide teaching and learning media. Most of the learning management systems provide substantial amounts of data regarding student interaction and their study behavior. At this stage, the research goal was not to analyze this data or to investigate their correlations with students' behavior, but the focus was on observation of their adequacy for future research. An obvious fact is that most of the educators/instructors only use a small percentage of the available data on these media, and a vast amount of the useful data that is hidden among the deeper layers of these platforms are ignored.

The existence of the data ranging from students' performance to their study and learning seems promising. As a case study, we reviewed the availability of the automatically recorded data for one of the large-scale engineering courses that is offered in a flipped classroom format. For each component of the course there is a section showing the time and period of the time that student have visited the posted material. Considering that student performance such as quizzes, exams, and lab marks are also recorded on the system, this information provides a good platform for a systematic data mining and data analysis studies.

Preliminary result showed evidence of adequacy of these data, and future studies will be undertaken to study their statistical significance. For example, based on the data extracted the LMS in Fall 2016 (shown in Table 1 and Figure 2), instructors discovered that there is a correlation between the length of video modules (even if they have quiz questions embedded), and the amount of time students spend on them. The data presented shows student viewing behavior for one set of technical programming modules. For the most part, students spent four minutes of viewing/note-taking/studying for every one minute of video footage. The first module in the set has a higher ratio, possibly due to the introduction of a new topic and format. As students become accustomed to the format, they return to consistent behavior for videos under 25 minutes in length. The longest video, Module #7, resulted in higher viewing values, potentially because students required more pauses and rewinding to remember material from the beginning of the lengthy video. Tutorial behavior also varies, as students may pause or repeat segments as they work through examples on their own. Additional behaviors and trends may be seen as data mining techniques are applied to the vast datasets available through learning management systems.

Table 1. Extracting the correlation between the length of video modules and the amount of time students spend on each module

Video Module Identifier	Length of Module (Minutes)	Average Time Spent on Module by Students (Minutes)	Approx. Ratio of Length to Time Spent
#1	8	56	1:7
#3	13	52	1:4
#4	14	71	1:5
#2	22	84	1:4
#6	23	94	1:4
#5	24	99	1:4
#7	30	179	1:6
Memory Diagram Tutorial	12	45	1:4
Extra Tutorial 1	15	87	1:6

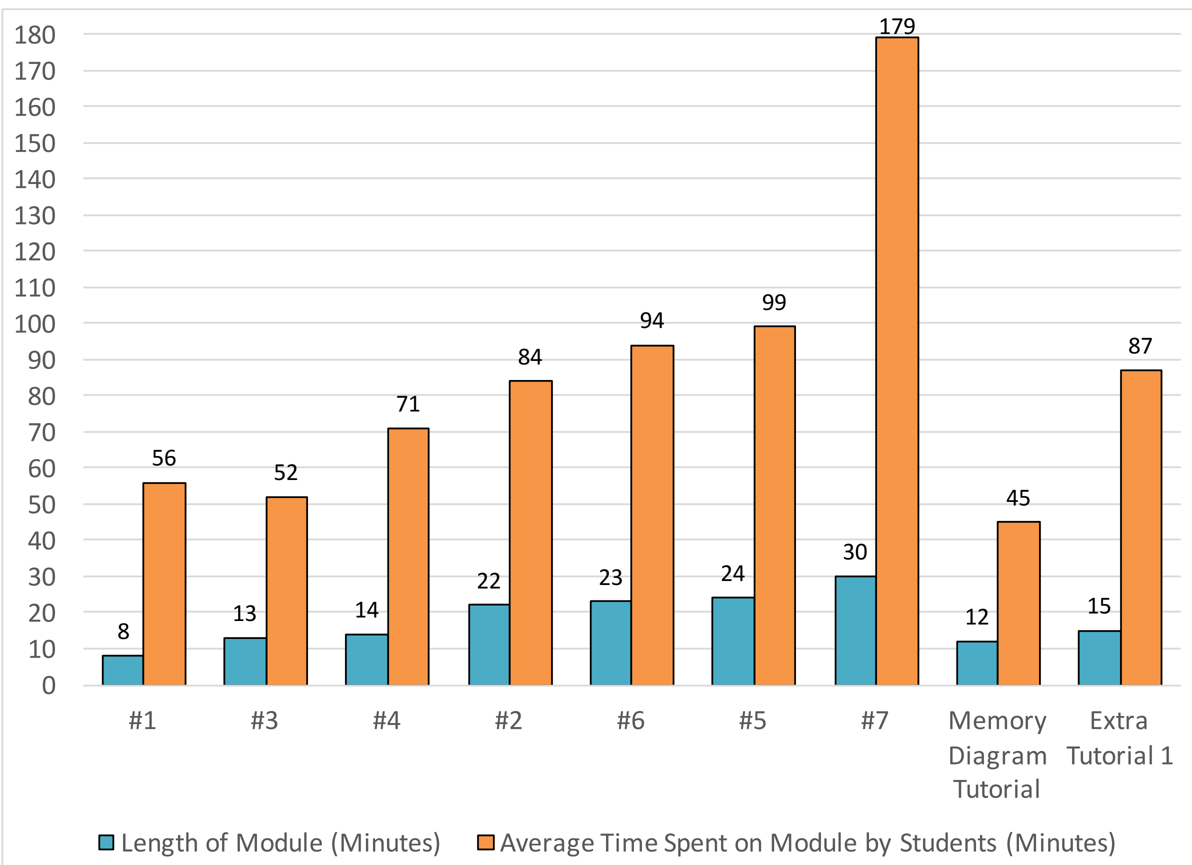

Figure 2. Comparing the effects of video length to time spent on videos by students

Additional data collection via questionnaires or surveys will continue to be used to support the recorded data, which will help in providing a set of guidelines and recommendations to improve the course curriculum, method of teaching, students' study habits, and learning behavior. The most recent set of survey data comes from the 2017 cohort. As stated above, students were asked to answer a combination of qualitative and quantitative questions following course completion. A selection of these results is provided in Figure 3. Based on this questionnaire, 80% of students agreed or strongly agreed that they found the ENGG 233 online lectures helpful, and 65% felt that this was when their most effective learning occurred. In comparison, only 36% felt that their most effective learning occurred during in-person tutorials. In regard to general learning, students indicated a preference for the developed online lectures over traditional in-person lectures. However, there was no statistical difference in their preference for a tutorial format. Finally, while flipped courses often create concerns regarding excessive workload, only 16% of students disagreed or strongly disagreed that the course workload was reasonable.

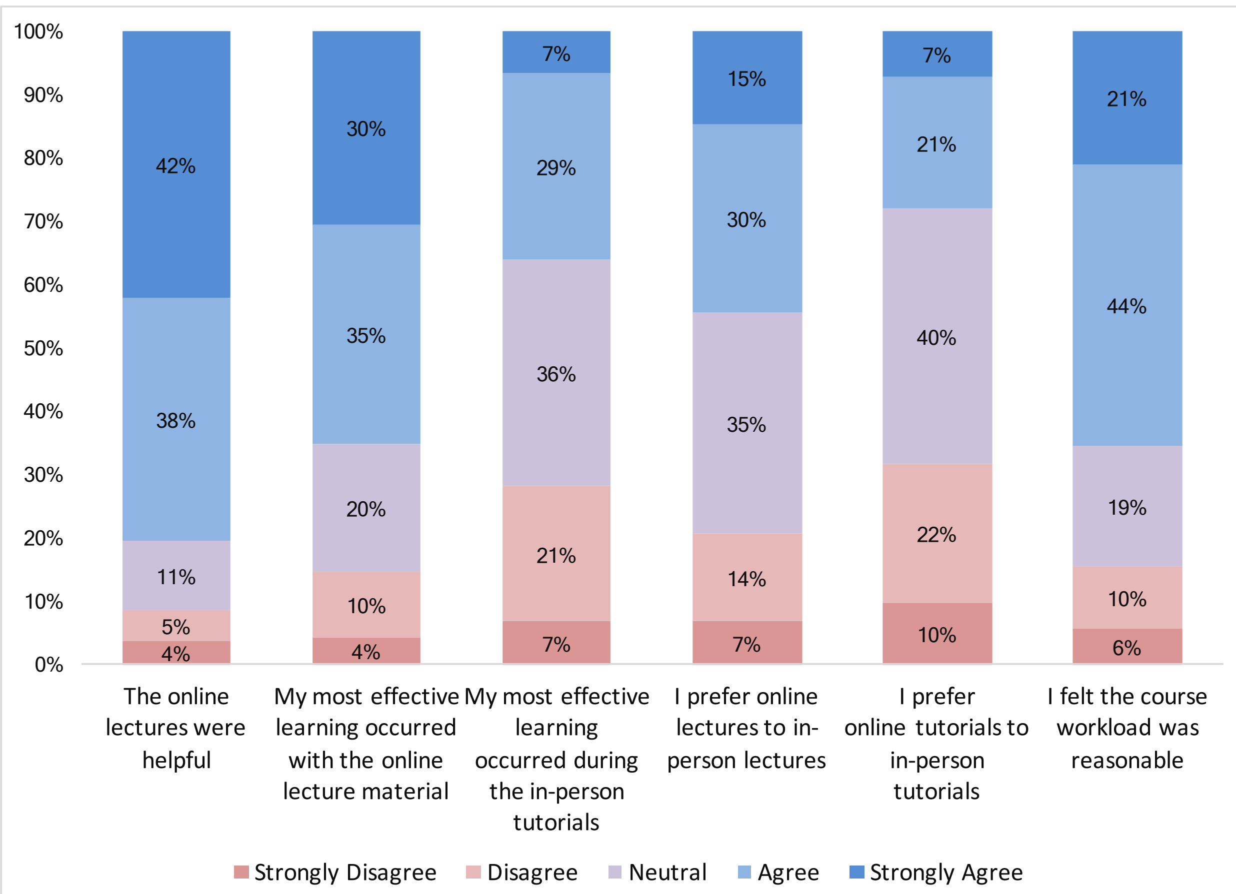

Figure 3. Student rankings regarding the flipped lecture format in a technical class.

In conclusion, both the technical and design focused implementations described in this paper have demonstrated successful development of online learning techniques, particularly the categorization of various video lesson types. The multi-offerings of courses using these techniques have resulted in evidence-based best practices and recommendations for other engineering educators interested in implementing similar methods in their own first-year courses, whether the concepts are based in technical engineering or engineering design.

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