Targeted Flipped Classroom Technique Applied to a Challenging Topic

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***Abstract*— The significant initial time commitment to create online content required for flipped classrooms may pose an obstacle to their implementation, despite the known learning benefits. We hypothesize that flipping only specific, problematic topics may still provide benefits to students with less instructor preparation. In this study, we targeted a flipped classroom toward a single, difficult course unit (the Reynolds Transport Theorem in fluid mechanics) to reduce the total time required for course preparation. Six lectures on this topic were converted to online videos and in-class time was used for group-based problem solving. Comparisons were made between a traditional lecture section (n=8) and flipped classroom sections (n = 15). A statistically significant improvement was seen when comparing exam performance on a question-by-question basis. Student survey responses about the method were unanimously positive, and students specifically noted the ability to rewatch sections of the video as a benefit to their learning. The interview responses also produced an unanticipated result. Students indicated that they preferred the partial approach to a hypothetical full course flip, stating they felt "it would get old." While the use of a targeted flipped classroom was investigated here to reduce the initial faculty time commitment, this finding may warrant future investigation on reaction to partial versus full course flipped classrooms.**

Keywords—flipped classroom; blended learning; fluid mechanics

I. Introduction And Background

Flipped classrooms are an active learning strategy that has experienced a recent growth in popularity [1]. Increasing availability of online and asynchronous delivery technologies has increased the ability for instructors to implement the technique. Conceptually, flipped classrooms consist of inverting the "traditional" classroom model [2]. Traditional class structures might make use of in-class conceptual lectures, with practice problems assigned to students for homework. A sample flipped classroom might instead present the lecture content to students as videos to be watched outside of class, utilizing the in-class time for group-based problem solving with instructor interaction. This strategy enables the interaction between students and the instructor to be more directed toward active and problem-based learning, and less focused on lecturing the students [2]. Detailed reviews of flipped classroom methodologies in engineering and research related to their use have been published by Bishop and Verleger [3] and Kerr [1].

Flipped classrooms have been previously discussed in literature [4], and their advantages have been documented. Mason et al. [5] showed that flipped classrooms allowed for more material to be covered, allowed for students to perform equivalently or better than those receiving traditional instruction, and were able to adapt quickly to the technique after initial struggles. Learning gains were also observed in implementations by Lemley et al. [6], Dang and Gajski [7] and Kim et al. [8]. One interesting observation from these studies was that the poorest performing learners seemed to benefit most in that the numbers of failing students were reduced [8], [7]. One previous study described flipping only a single course module [9], with positive feedback from students and faculty.

One challenge to applying a flipped classroom pedagogy is that a significant initial time commitment may be required of faculty implementing the technique for a course [5], [10]. This is caused primarily by the need to prepare the videos or other online content that allows students to work on the theoretical material independently. During a typical semester, this may consist of online material equivalent in content to 30-45 lecture periods. The time commitment obstacle may be particularly challenging for faculty members still on the tenure track, who may be attracted to active learning methodologies, but may be hesitant to invest the time required as a result of rigorous scheduling demands.

In the present study, we investigate the impact of a partial flipped classroom activity that was targeted at the instructor-identified "most challenging" topic in a course. Partially flipped classrooms have not been thoroughly described in literature, but may provide instructors with options to implement the technique without being subject to the full preparation time impacts. The intent of this activity was to observe whether learning benefits for students can still be achieved through this partial implementation, reducing the preparation time commitment, and/or allowing for incremental transition of the flipped material over several consecutive course offerings.

II. Methods

The course used for this investigation was a fluid mechanics course intended for junior level engineering students. The specific topic being targeted was the Reynolds Transport Theorem, which the instructor identified via prior experience as a particularly difficult topic for students. This is a topic that is often described as challenging for students, but that serves as foundational knowledge for several subsequent courses. The Reynolds Transport Theorem unit occurs about one third of the way through the traditional semester. The unit, initially consisting of six, traditional 50-minute classroom lectures, was converted to a series of six lectures delivered as online (YouTube) videos (Fig. 1). The videos were created using Doceri [11], a screen recording software for iPad tablets, and consisted of slideshow presentations with recorded narration and text highlighting. These videos ranged from seven minutes to sixteen minutes in length. The reduction in duration, as compared to 50 minute lecture periods, was achieved by focusing primarily on conceptual explanations and removing solved examples, and by the lack of student questions.

Students were assigned one video prior to each of six consecutive class periods. The first five minutes of each of these class periods was devoted to a brief (2-3 question), open notes quiz on knowledge-level content contained in the videos. The intent of the quizzes was to ensure student compliance with the assigned viewing. The class period following each video was dedicated to in-class group problem solving. Students were divided into groups of 3-5 students, and were assigned to work on sets of two or three problems relevant to the lesson. The instructor spent time circulating throughout the room to facilitate problem solving and address common sticking points for the whole class. The problems primarily focused on setting up approach to problems and identifying tricky points in the solution, rather than simply finding numerical answers. In addition to the in-class exercises, students were assigned a problem set on the topic (similar to that assigned for other units in the course) for homework.

The effectiveness of the activity was assessed through various means. Data were collected and compared between a “control” offering of the course using the traditional lectures and two subsequent “experimental” offerings featuring the flipped classroom for the targeted unit. All offerings were taught by the same instructor. Student numbers for these courses were relatively low, with n=8 for the control group and n=15 total for the two experimental sections combined.

Several graded assessments from the course were used to quantify student performance as related to the intervention. Homework sets 1-3 and Exam 1 all dealt with course content prior to the delivery of the Reynolds Transport Theorem material; grades from these assessments were used to establish baseline performance. Homework 4 and a portion of Exam 2 dealt with the Reynolds Transport Theorem (post-intervention) content. Homework questions were identical between control and experimental sections, while exam questions were changed slightly to maintain exam integrity, while retaining the approach and concepts being assessed. The students’ overall scores on these baseline and post-intervention assessments were used to compare the control and experimental group performance. Students who failed to turn in any of the homework assignments were eliminated from these analyses. In addition to aggregate homework and exam scores, each of the seven problems from Exam 2 that explicitly dealt with the Reynolds Transport Theorem was scored as Correct, Partially Correct (>50% points awarded) or Incorrect. Students receiving scores in each category were quantified on a problem-by-problem basis and comparisons were made between the control and experimental groups.

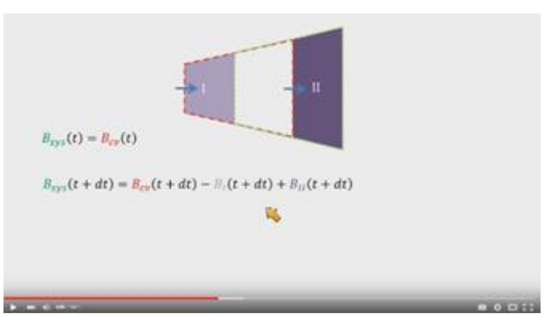

Fig. 1. Screenshot taken from the first online lesson video

In addition to the quantitative data discussed previously, a semi-structured interview was performed for the experimental group, which asked free response questions about student perceptions of the flipped classroom portion of the course. A list of questions used in the interview may be found in the Appendix.

III. Results

A. Comparison of Aggregate Homework and Exam Scores

The results of the homework and exam overall grade comparison are shown in Table 1 and Table 2 respectively. It is important to note that the experimental group experienced significantly higher baseline scores, which may be a confounding factor in the analysis. The homework comparison indicated that students in the experimental group showed a slightly larger drop in score from pre- to post-intervention assignments. The exam grade comparison showed that the experimental group demonstrated a slightly greater improvement from Exam 1 to Exam 2 than did the control group. In both cases however, analysis indicates that these trends lack statistical significance, which may in part be due to the small number of participants.

B. Comparison of performance on Reynolds Transport Theorem-related exam questions

The results from the item-by-item comparison of Exam 2 scores are listed in Table 3, and shown graphically in Fig. 2. Again, this represents the student scores on exam problems specifically related to the content in the flipped classroom segment of the course. The percentage of students receiving correct answers increased from the control to the experimental group, with a commensurate decrease in wrong answers (partial scores stayed approximately constant). This change was found to be statistically significant with the chi-squared test. However, caution should be used when generalizing these results both due to the small sample size and the higher baseline scores achieved by the experimental students.

C. Student interview results

The semi-structured interview was conducted with five volunteer students who participated in the experimental group. The five students all indicated that they felt their own performance in the course met their expectations. The students' reaction to the flipped classroom intervention was unanimously positive. All students indicated that they felt that they learned more in the flipped classroom portion of the course than in the traditional lecture portion, and several commented that they felt that they learned more than in their other courses as well. They all felt it helped their grade for the unit in question. When asked what they would do if they were teaching the course, one said, "Definitely do it again." The students particularly praised the ability to learn at their own pace, using phrases such as: "pause and rewatch," "slow down and take notes" or "watch... several times." One specifically appreciated the opportunity to rewatch in order to clarify portions of their own notes that were unclear. Students identified some weaknesses of the technique as the inability to ask questions during the video. One student would have preferred the videos to include faculty-worked examples to watch prior to coming to class, and "would still watch more than once [even if the time] extended to 15-20 minutes."

One student made a comment during the interview that was unexpected by the researchers, but bears particular importance to the partial, targeted flipped classroom activity. Specifically, a student noted that they felt that using the flipped classroom only for a portion of the class was a significant benefit. After this point was made to the researchers, the remaining four interviewees were prompted about the issue, and all agreed that they felt a partial implementation was preferable. Several students mentioned that they enjoyed the "variety" and specifically felt an incentive to come to the flipped classroom portion of the course and that it "made class more interesting." They felt that if the whole class used the flipped classroom technique, they "wouldn't watch, or it would get old" and one specifically stated that they "wouldn't want to do [it] every day." Students expressed mixed thoughts on whether a large number of their courses utilizing flipped classrooms would affect their perceptions, but one stated that it would be "too much." It is important to note that because the finding that students preferred the partial flip to a hypothetical full flip was not anticipated, it is difficult to extrapolate past qualitative, anecdotal conclusions regarding that issue. However, this preliminary finding may serve as motivation for further research that specifically compares partial to complete flipped classroom implementations to compare student learning and reactions between the methods.

TABLE I. HOMEWORK OVERALL GRADE COMPARISON

Group	***N***	***Baseline***	***Post Intervention***	***Difference***
Control	8	8.6	8.3	-0.37
Exptl.	15	9.4	8.6	-0.77
T-Test P	0.19			

TABLE II. EXAM OVERALL GRADE COMPARISON

Group	***N***	***Exam 1 Baseline***	***Exam 2 Intervention***	***Difference***
Control	8	63.0	76.9	12.9
Exptl.	15	71.0	84.3	13.3
F-Test P	0.088			

TABLE III. COMPARISON FOR EXAM 2 ITEMS RELATED TO REYNOLDS TRANSPORT THEOREM

Group	***N***	***%Right***	***%Partial***	***%Wrong***
Control	8	50%	18%	32%
Exptl.	15	73%	17%	9%
Chi Sq. P	0.001			

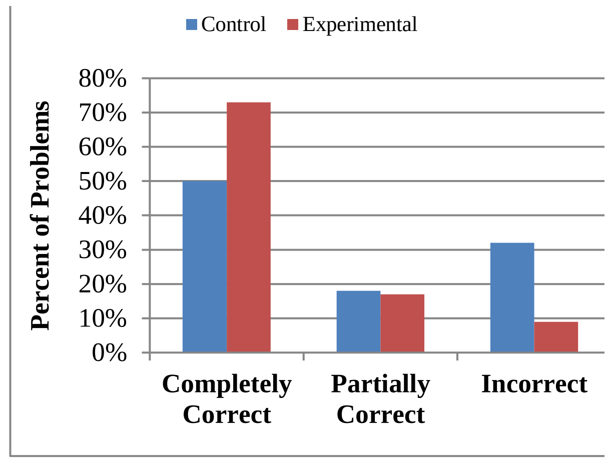

Fig. 2. Comparison for Exam 2 items related to the Reynolds Transport Theorem.

IV. CONCLUSIONS

A partial flipped classroom activity was implemented in a junior level fluid mechanics course, targeting only an instructor-identified difficult topic. The flipped classroom was targeted at the course unit on the Reynolds Transport Theorem, a particularly challenging, but important, undergraduate topic. The intervention significantly reduced the time commitment required to develop the course material required for the flipped classroom for the entire course (6 lectures vs. 45 lectures for a complete flip).

Overall, quantitative analysis had mixed results. No statistically significant differences were observed in the aggregated homework and exam grades, though higher baseline scores for the experimental group and the small sample size may have served as confounding factors in this comparison. However, a positive and significant effect was observed on student performance on particular exam questions directly related to the flipped classroom intervention. Further study may be warranted to allow more detailed conclusions about student performance to be drawn.

Student response to the flipped classroom activity was overwhelmingly positive. Students in particular identified the ability to rewatch difficult sections as a benefit of the online video portion of the activity. One interesting result related to the partial, six lecture flip was that students indicated that they preferred the activity to only encompass a portion of the course. They praised the incentive to come to class offered by the "variety" of this unit, and one student specifically mentioned that they felt that the entire course being flipped would "get old." While additional research would be needed to concretely assess the relative benefits of partial- versus full-course flipped classroom implementations, this unexpected result may serve to motivate research on partially flipped classrooms from a student response perspective.

Overall, this work demonstrated that some learning benefits are available to students from a partially flipped classroom, that difficult topics can be targeted to make the most of these learning benefits, and that instructors may be able to achieve these benefits while saving time in course preparation by targeting a subset of topics or by preparing for a full course flip incrementally.

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Appendix - Semi-structured Interview Questions

1. Did you enjoy the course?
2. How much do you feel learned in the course?
3. Do you feel that you did well in the course?
4. Tell me about your opinions of the flipped classroom.
5. Tell me about your positive experiences with the setup.
6. Tell me about the negative experiences with the setup.
7. Explain how your experiences differed from your courses with a more traditional setup.
8. Do you feel that the setup helped or hurt your course grade?
9. How would you change the setup if you were teaching the course?
10. Any other comments you have about the flipped classroom setup?