Flipping Unplugged: An Experience Report

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***Abstract*—This Research-To-Practice Full Paper discusses the use of the flipped classroom format. Within the CS community, numerous papers discussing the use of flipped classrooms have appeared in recent years. We discuss the use of flipped classroom techniques without requiring the use of modern digital technology. We argue that the principal goals of flipped classrooms do not a priori require such technologies, and that instructors should not feel limited by a lack of access to technology when considering flipped classroom designs. This paper gives an experience report regarding the use of "unplugged" flipped classroom techniques in a computing history and ethics course over the last ten years.**

1. Introduction

The use of the flipped classroom format [1] has become a popular topic for educators. Within the CS community, numerous papers discussing the use of flipped classrooms have appeared in recent years. We note, as examples, four separate papers discussing flipped classrooms in the SIGCSE 2017 proceedings ([2], [3], [4], [5]), and four papers in the SIGCSE 2018 proceedings ([6], [7], [8], [9]).

With the advent of so many papers, survey literature regarding flipped classrooms is starting to appear as well. An early survey by Giannakos and Krogstie [10] reviewed thirty-two peer-reviewed articles appearing prior to 2014 in the CS literature, summarizing existing findings and suggesting directions for future research.

Of particular interest to us in the survey by Giannakos and Krogstie is a brief discussion on the types of technology used in flipped classrooms. Twenty-nine of the thirty-two articles surveyed explicitly noted the use of various forms of digital technology used in flipped class rooms. Video lectures were the most common technology cited, but other technologies were also noted (e.g. intelligent tutoring systems, animated readings, simulations). It is hard to find a discussion of flipped classrooms that does not highlight the use of digital technology to facilitate content delivery outside of the classroom. Indeed, the use of such seems to be assumed in any such discussion.

Such a focus on digital technology in flipped classrooms may be misleading. Content delivery outside of the classroom experience need not be mediated by digital technology in order to facilitate a flipped classroom. Traditional techniques involving books, paper, and pencils can be used to great effect.

This paper gives an experience report regarding the use of "unplugged" flipped classroom techniques in a computing history and ethics course over the last ten years.

2. Background

The phrase "flipped classroom" is traditionally used to refer to any course structure in which original content delivery is moved outside of the traditional classroom setting. Students are expected to complete content-delivery activities (e.g. watching video lectures) prior to attending class. Classroom time is then spent on more interactive tasks (e.g. working through examples).

Coursera [11] gives four "golden rules" for flipped classrooms. In-class activities should require students to actively retrieve, apply, and/or extend content received outside of class. In-class activities should be highly structured. Students should be provided with real-time feedback on those in-class activities. Completion of the in-class activities, and the prior preparation for those activities, should contribute a small yet significant amount to student grades.

King [1] is traditionally cited as the first reference to flipped classrooms, though the work does not use the terminology of "flipping". King writes about the use of classroom time for the construction of meaning in students, rather than merely the transmission of information. Lage *et.al.* [12] first published research on the use of flipped classrooms at the college level; in that work, content delivery was accomplished through the use of VCRs and computers.

As noted earlier, Giannakos and Krogstie [10] performed an analysis of thirty-two peer-reviewed articles on flipped classrooms in CS. They noted three significant challenges to the adoption of flipped classrooms: high initial costs in preparation time, student resistance to the non-traditional structure of the course, and decreased classroom attendance.

3. Course Overview

CS-300 (The Computing Professional) has been a required course for CS majors at Kettering University for the

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past ten years. The course has an equal focus on computing history and computing ethics. Students are required to research an important figure or artifact from the history of computing, as well as a contemporary issue in computing ethics. Historical research is informed by considerations of the significance of the artifact's "value proposition" [13]. Ethics research is informed by a required analysis using the technique of "paramedic ethics" [14]. Both research projects culminate in an oral presentation and a written research paper. A midterm examination and class participation complete the student's overall course grade.

Early in the development of this course, it became apparent that traditional lecture-oriented content delivery was undesirable. We were unfamiliar with much of computing history at the beginning of the course; our unfamiliarity was not uncommon among CS instructors [15], but still lead to a natural reluctance to presenting ourselves as "authorities" on the material. Also, due to outside constraints, the course was often scheduled in 120-minute blocks beginning at 8am; it quickly became apparent that a more active classroom format was desirable (even necessary!). At the same time, the course material does not obviously lend itself to frequent constructive activities, as is true of algorithm-oriented CS courses.

As a consequence, we switched to a flipped classroom model for CS-300 in 2009, but largely without the use of digital technologies. Students are assigned readings in both computing history and ethics textbooks before each class session. (Of the four textbooks used in the course, three are conventional printed textbooks, while the fourth is available in both printed and digital formats.) At the beginning of each session, students are required to complete "one-minute papers" [16] on each set of readings. Students supply answers to two questions: "what was the most significant thing you learned in the reading?", and "what unanswered question do you have about the reading?" Students write their answers on notecards provided by the instructor.

After all students have completed their cards, the instructor leads a classroom discussion based upon the questions written on the notecards. The instructor reads questions from the cards, offering them to the classroom for discussion and comment. Duplicate or off-topic questions are suppressed by the instructor. After class, the notecards are "lightly" graded, primarily to ensure that students are on-task. These cards then form the basis for a course participation grade (twenty percent of the student's overall course grade).

Note that, even though digital technologies are not essential to the delivery of content in this course, the course still follows the basic model of a flipped classroom. Students are responsible for content acquisition prior to class: in this case, through completing required readings. Classroom time is then used for construction of meaning, through activities suggested by the questions raised by students.

4. Evaluation

As this course has been taught using a "flipped unplugged" model of instruction for the past ten years, it is difficult to construct meaningful post-hoc evaluations of the effectiveness of this model without a basis for comparison.

TABLE 1. READING PARTICIPATION RATES AND GRADE CORRELATION

Term	N	# Fully Prepared	%	# Partially Prepared	%	Grade Correl.
2009 Summer	20	15	76	17	86	.34
2009 Fall	17	14	83	16	92	.31
2011 Summer	29	23	80	25	87	.49
2011 Fall	28	22	80	24	87	.69
2013 Summer	30	25	82	26	87	.36
2013 Fall	26	23	89	24	94	.67
2015 Summer	27	25	92	26	95	.41
2015 Fall	24	17	72	20	84	.53
2016 Summer	15	13	89	14	93	.09
2016 Fall	25	21	83	22	89	.32
2017 Summer	25	21	85	22	89	.32
2017 Fall	23	20	87	21	91	.32

In Table 1, we give average participation rates on the unplugged reading assignments for the course since the use of the "flipped unplugged" model was instituted in 2009. Rates are based on the instructor's scoring of the one-minute papers, averaged over the entire course. Students earning full points on the assignment are listed as "fully prepared"; students earning non-zero points are listed as "partially prepared" (which includes fully prepared students).

Table 1 shows that, on a given day, the vast majority of students come to class fully or partially prepared for class discussions, based on their unplugged readings. Due to the relatively small sample sizes, the use of percentages in the table can be deceiving; accordingly, we show participation both in actual numbers of students and percentage of enrolled students. In most cases, the number of underprepared students averages to a handful of students; of course, this handful of students includes those who are absent for the usual reasons (*e.g.* travel, interviews, illness).

Table 1 also shows computed correlations between an individual student's participation rate on reading assignments and the weighted average of all other graded assessments in the course. The listed correlations generally show a modest correlation between reading participation and other course performance, ranging from $0.3 - 0.5$. [1] This suggests that participation in the flipped reading assignments may have a positive effect on overall course performance.

5. Discussion

5.1. Flipped Classroom Structure

We return to Coursera's "four golden rules" for flipped classrooms [11] and discuss them in the context of our "flipped unplugged" model.

1. In Summer 2016, the single outlier term, student performance in that term was unusually high; all students earned grades of B or higher. This leaves less room to discriminate between student performance in any calculation of correlation. The smaller number of students enrolled that term may also have affected the correlation statistic.

5.1.1. Content Received Outside Of Class. The model of classroom discussion here clearly requires that students complete their assigned readings prior to each class session, in order to complete the one-minute papers. This model requires a mindset adjustment for some students, who have been taught that "the textbook is dead" [17], and been told in University orientation classes that readings assigned by professors are usually optional [18], [19]. Still, once students realize that the instructor is serious about the flipped model of instruction, students quickly adapt.

This model also requires that students have access to the required readings prior to class. While this would seem to present fewer problems with "mere" textbooks than with the variety of technological artifacts often used in flipped courses (e.g. streaming videos, dynamic website exercises), even access to physical textbooks can be problematic. Our "brick and mortar" campus bookstore at Kettering University had difficulties supplying textbooks in a timely fashion, leading to difficulties as students resorted to alternative means for completing the readings, and instructors were forced to restructure the course schedule. Later, the campus bookstore was replaced by an online bookstore; now, students who wait to purchase their books until after arriving on campus (*e.g.* because of late registration) can be subject to the vagaries of online booksellers and their shipping dates.

5.1.2. Highly-Structured Activities. Each day's classroom discussions are based directly upon the readings, providing structure to the course. At the same time, the discussions can be wildly different from term to term, depending on student and instructor interest, as well as contemporary events. "Highly structured" does not have to dictate an identical set of activities in each term.

Of course, the readings chosen by the instructor need to be relevant and engaging. As with many courses, choosing readings to make computing history engaging, and computing ethics relevant, is a challenge. Continued curation is gradually leading to a set of readings that are engaging for most, and at least tolerable for the rest.

5.1.3. Real-Time Feedback. Timing does not permit real-time grading of the one-minute papers. But students quickly observe that the one-minute papers are used to guide each day's activities, giving them greater motivation to complete the assignments. The instructor's choice of questions also shows students what types of questions are likely to generate further discussion, anecdotally leading to better questions as the term progresses.

5.1.4. Significant Portion Of Course Grade. Twenty percent of the overall course grade seems to be sufficiently motivating for students. Some students even come to class each day with their one-minute papers already completed.

5.2. Challenges of Flipped Classrooms

We also consider the challenges to adoption of flipped classroom techniques noted by Giannakos and Krogstie [10].

5.2.1. High Initial Costs In Preparation Time. The chief preparation costs for unplugged readings involve the selection of readings to be discussed. Without the additional overhead involved in preparing digitally-enhanced activities (e.g. video recording, animation design, simulator development), it seems that unplugged reading selections can be performed with a reasonable time expenditure.

5.2.2. Student Resistance. As noted earlier, students have "learned" (explicitly or implicitly) that textbook reading is optional for most courses [18], [19], and need to have their expectations altered for unplugged classrooms. A certain amount of initial resistance is usually encountered. However, once students see that the instructor is, in fact, relying upon the flipped readings to inform classroom discussions, and that the instructor is serious about grading the one-minute papers, students quickly comply with the course structure, usually within the first couple of class sessions. (Kettering University also has a small population of CS students; the "word on the street" moves quickly, instructing students as to how to succeed in courses offered by different instructors.)

5.2.3. Decreased Classroom Attendance. The preparation rates shown in Figure 1 would seem to show that classroom attendance rates remain generally high for this flipped unplugged model. Accounting for students who attend class without completing the unplugged preparatory assignment, attendance rates are probably slightly higher. Students understand the expectation for regular attendance and do their best to be present.

6. Related Work

The literature on courses in computing history tends to focus more upon advocacy for such courses, rather than discussing the pedagogy to be employed. Works advocating for computing history courses, be they older works (*e.g.* [20]) or newer works (*e.g.* [21]), implicitly assume an instructional model based on classroom lectures. An older survey [22] explicitly notes that most computing history courses at the time were lecture-based; seminar-style courses were seen as a "vanishing luxury".

More recent works on computing history courses (*e.g.* [21], [23]) discuss different types of student assessments in order to make the course more appealing to students. Particularly popular is the use of technically-oriented assignments (*e.g.* writing programs in historical programming langugages) to supplement traditional textbook readings and the writing of essays and research papers. Draper [23] also uses "one-minute papers" [16], but only at the end of each class; the activity is used primarily to generate interesting test questions.

In contrast, the literature on teaching ethics in computing courses is rich and diverse, and consequently difficult to summarize. A random sampling of literature on ethics courses finds approaches emphasizing writing-intensive assessments [24], mock trials [25], creativity [26], fictional

narratives [27], and contemporary media [28]. Many other approaches are undoubtedly in use.

Most articles on computing ethics courses assume some sort of discussion-oriented format in use, though few describe how that discussion is facilitated. One notable exception is Sanders [29], which describes a discussion-oriented format for teaching ethics. Students are motivated to engage in discussions through a requirement to cite other students in their written assessments. Even with such a requirement, Sanders noted problems with student attendance and students completing readings prior to class.

7. Conclusion

Many of the goals of flipped classrooms can be met without the use of extraordinary digital technologies. Key principles for effective flipped classrooms [11] can be followed without commonly experienced pitfalls [10]. Instructors who might be reluctant to adopt flipped pedagogies because of technological limitations in their teaching environment should consider the use of traditional techniques to achieve their desired goals.

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