A Hybrid Flipped First Year Engineering Course

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Abstract

A hybrid flipped course has been used for two years in a first year engineering course at Rowan University, Glassboro, NJ, USA. In the Fall 2013 semester there were 12 sections of 20 – 25 students. The course is considered a "hybrid" because the textbook and a majority of the homework exercises are delivered online. The course is considered "flipped" because students are quizzed (online) on the course ebook before material is covered in class. This allows instructors to focus on more advanced and active learning during class time.

The purpose of this paper is to describe the hybrid flipped course format in detail, focusing on the ebook and online homework. The results of surveys of students and instructors are used to explore the functionality of hybrid flipped courses.

Levels of satisfaction with the online aspects of the course were high amongst students and teachers. Pathfinder was somewhat successful at getting students to prepare for class, primarily by creating an atmosphere of expected preparation, which was accentuated by the fact that graded online exercises were required prior to class. While a number of active learning techniques were employed in the Fall 2013 semester, more are envisioned for future course offerings.

Introduction

A hybrid flipped course has been used for two years in a first year introductory engineering course at Rowan University, Glassboro, NJ, USA. The course is considered a "hybrid" because the textbook is delivered online (an ebook), as are a majority of the homework exercises. The course is considered "flipped" because students are quizzed (online) on the course ebook before material is covered in class. This allows instructors to focus on more active learning during class time.

The purpose of this paper is to describe the hybrid flipped course format in detail, focusing on the ebook and online homework. The results of surveys of students and instructors are used to explore the functionality of hybrid flipped courses. Levels of satisfaction with general online aspects, feedback, and online solution methods are explored. Student preparation for class is evaluated, as is the use of active learning techniques by the teachers.

Background

Hybrid courses typically consist of face-to-face classroom interaction and online computer-mediated communication.[1] In the current research literature, the term hybrid course is often used interchangeably with the terms "hybrid instruction," "blended instruction," "technology-mediated instruction," "blended learning", and "mixed-mode instruction".[2,3] Blended learning is a form of technology-based learning, which emerged in the 1960s and 1970s on mainframes and mini-computers.[4] Face-to-face classroom activities in a hybrid course may include traditional lecturing, labs, research, and group problem solving along with quizzes and examinations.

Accompanying the face-to-face classroom activities, students may learn the course material through computer-mediated activities such as online lectures, online demonstrations, online quizzes, synchronous and asynchronous (any time, any place) discussions, and group work sessions.[5] Online lectures and demonstrations can either be pre-recorded or streamed live while the synchronous and asynchronous discussions can be administered via email, text messaging, online conference calls, an electronic course management system, or even social media websites. Additionally, the online quizzes and group work sessions can either be graded by the instructor at a later time or instantaneously and automatically by the administering web-based tool, providing students instant feedback and assessment.

The hybrid course model has been adopted successfully by many universities in a variety of disciplines, including engineering[2], communications[6], biology[7], and library science[8]. Despite the successful implementation of the hybrid course model, concerns over how this method impacts students' learning experiences, especially how frequent altering of course delivery technology impacts students' learning, and class attendance have been raised.[6,9,10] For instance, a student at University of Wisconsin-Madison in the College of Engineering has been quoted in stating,

> "I feel like a massive amount of content is being thrown at me in a short amount of time, and often this feels overwhelming and I don't absorb it all. And when I am confused [during the online lecture] I can't ask a question until Wednesday morning and I usually have forgotten what or why I was confused."[11]

With regards to attendance, it has been argued that, if high quality materials are online, then students will have an excuse to be absent from face-to-face class time.[6] Juxtaposing these concerns, a study by Riffell and Sibley showed that students in a large, introductory environmental biology course at a major, public university reported a high level of interaction with the instructor and that they read the course material more frequently and studied in groups more often than compared to students taking the same course in the traditional setting with passive lectures.[7] Additionally, students reported positively that they like the ability to pause pre-recorded online lectures and demonstrations and write down notes and that they like the ability to watch material over again in order to maximize their learning.[2] Moreover, "a hybrid course has the potential to enable instructors to offer students a greater range of learning avenues and uphold educational and academic design standards, even when instructing large classes and non-traditional students living sizable distances away from campus," according to a 2010 meta-analysis study conducted by the U.S. Department of Education.[12]

In a flipped course, students are first introduced to course material by reading, watching video, completing activities, and/or taking quizzes; concepts are then reinforced through lecture, discussion, and active-learning in class.

The basis of engineering is hands-on, active learning. For that reason, engineering instructors are encouraged to actively engage their students with the course material through trying different instructional techniques. Several studies have examined engaging students through flipped classrooms. The contributions by Lage et al.[13], Lage and Platt[14], Felder and Brent[15], Prince[16], and Klionsky[17] have provided a summary of the benefits of a flipped classroom. There has been some concern that the use of active learning activities in the classroom is consuming class time that

could be spent on lecturing new material, especially since lecturing is still the primary method of covering materials. Still, despite lecturing being the more traditional method of conveying material, it may not be the most effective instructional method to ensure student understanding of the material.[18] The goal of creating an active learning environment by using a flipped classroom is to involve students in their own learning through classroom activities and group work, replacing the traditional role of passive listeners that students have historically taken on in the classroom.

Engineering's foundation is problem solving, and active learning is a key component in improving students' problem solving skills. Once these skills are developed, students should be able to understand complex subject matter and transfer their knowledge to new environments and situations. Engineering is not a subject that can be mastered through simply memorizing the lecture notes.[15] It is a field that requires the application of the knowledge that has been introduced to the students. Prince found that active learning strategies resulted in an increase in student engagement, as well as the amount of material they were able to learn, when these methods were compared to the more traditional lecture methods of instruction.[16]

A method that has allowed instructors to use active learning techniques in the classroom as they engage students, without losing the time to cover new material, is to invert the classroom or flip the classroom. An inverted or flipped classroom involves using video, handouts, or other previously prepared materials students review before meeting for the course. This requires students to use out-of-class time to initially absorb material on their own.[14] The access to these materials has become even easier through the use of Internet sites to store, and allow easy access to, the learning material. This allows the instructor to spend the in-class time leading students through engaging activities, without giving up the time to cover valuable course content. Here the role of instructor shifts, and the class is no longer instructor centered. Instead, the student is the one taking center stage and taking the initiative to prepare for class ahead of time, so that they can fully participate in class activities.[13] This allows engineering students to master problem-solving, through the application of the skills to different in-class scenarios.

A flipped class allows students to have time to work out problems while they have the instructor available to guide them through the problem as needed. Still, there is a requirement that there is a method of making sure that students are performing the before class preparation that is required. Usually a pre-class, online quiz is utilized to ensure student will perform the tasks required before class, so that they are ready to participate in the in-class activities. This also allows the instructor to use the results of the quizzes as a discussion point for the class, as well as a guide to adjust in-class plans, and to review areas that the students may be underperforming in. Flipped classrooms allow real time assessment of a student's progress, to allow the instructor to address any pressing student issues with the material. Introduction of this method can be utilized in even large lecture halls, and without the use of expensive technology.[17] In addition to its accessibility, this method of instruction assists the students in developing their communication skills, as well as conducting a self–evaluation of their comprehension as they progress through the course material.

Course Description

The hybrid flipped course described here is Freshman Engineering Clinic I, an introduction to engineering course taken by all freshman engineering students at Rowan University. There were twelve sections of 20 – 25 students each in Fall 2013. Sections were interdisciplinary, with chemical, civil & environmental, electrical and computer, and mechanical engineering majors mixed. The course met twice a week during the 15 week semester, a 50 minute "lecture" and a 160 minute laboratory session. The purpose of the course was three-fold: (a) help students make a good transition to college; (b) introduce students to engineering; and (c) prepare students for the engineering curriculum by teaching them a number of basic skills.

The online aspects of the course are delivered using PathFinder, a website developed at the university. The course chapters are given in the PathFinder Plan Tab shown in Figure 1. Semester projects are used to reinforce course topics. Students work on the project during the lab period. Projects are chosen by each instructor.

PathFinder | Manage | Plan | Read | Work | Team | Help

		BEFORE				AFTER			
Chapter	Guide	When	Won	Sum	Done	When	Won	Sum	Done
PathFinder	◂	No Future Dates	88.9	80/90	9/9	No Problems	0	0/0	0/0
RU Introduction	◂	No Future Dates	100	80/80	8/8	No Problems	0	0/0	0/0
Academic Success	◂	No Future Dates	97.8	88/90	9/9	No Problems	0	0/0	0/0
Engineering Introduction	◂	No Future Dates	97.7	127/130	13/13	No Problems	0	0/0	0/0
Presenting Technical Information	◂	No Future Dates	97.5	78/80	8/8	No Future Dates	99.2	119.1/120	4/8
Engineering Tools - Basic Software	<5	No Future Dates	96.4	106/110	11/11	11/18/2013 8:30 AM	0	0/40	0/4
Engineering Communication	◂	No Future Dates	93.3	56/60	6/6	No Problems	0	0/0	0/0
Rounding and Significant Figures	◂	No Future Dates	92.5	37/40	4/4	No Future Dates	93.4	204.5/219	30/30
Uncertainty	◂	No Future Dates	80	40/50	5/5	No Future Dates	91.5	164.7/180	9/9
Engineering Problem Solving	▸	12/15/2013 8:00 AM	100	80/80	8/8	12/15/2013 8:00 AM	0	0/303	0/13
Engineering Design	◂	No Future Dates	96	48/50	5/5	No Problems	0	0/0	0/0
ALL CHAPTERS			95.3	820/860	86/86		94.1	488.3/862	43/64

Figure 1: PathFinder Plan Tab

PathFinder is an active website coded in html, asp.net, c#, JavaScript, and pathML, a PathFinder specific markup language. Content consists of images, html, xml, and mathML. Equations coded in mathML are used both for display and solving exercises. The website assembles ebooks on the fly using pathML to access content as needed. Content is stored modularly, so a given variable, equation, article, etc. is stored once but can be called up to form a part of any ebook chapter. PathFinder ebooks have randomly selected and generated exercises that are automatically graded. The website provides instantaneous feedback to both students and professors regarding performance on online exercises.

The learning sequence supported by PathFinder is:

- Prepare for class;
- Demonstrate preparedness by completing BEFORE exercises;
- Attend class and participate in active learning; and
- Demonstrate skill acquisition by completing AFTER exercises.

PathFinder ebooks incorporate online exercises to achieve the second and fourth steps. BEFORE-exercises motivate students to read chapters before class. AFTER-exercises provide students an opportunity to demonstrate what they've learned after materials are covered in class. Both types of exercises constitute a significant portion of a student's grade.

Students are assigned exercises from banks, so they get different problems. Calculation problems have the input values randomly assigned, so even if two students get the same problem, the given information will be different. Offline problems are used to provide a more open ended problem-solving experience. In the hybrid flipped course described here, students complete 9 BEFORE and AFTER online problem sets, one for each chapter. The number of offline problem sets varies by instructor. Each problem set contains multiple problems.

Figure 1 is an example of a student's PathFinder Plan Tab. Students use this tab to plan ahead, access ebook chapters and BEFORE and AFTER exercises, and obtain feedback. The "Chapter" column contains links to the ebook chapters. The "Guide" column provides information about upcoming due dates. A left pointing triangle means that all due dates in a chapter are past. A right pointing triangle indicates that there is at least one assignment left, but it is more than a week away. A red "<#" indicates an assignment is due within # days, e.g., the AFTER-exercises in the Engineering Tools chapter were due in 5 days when this Plan Tab was accessed.

BEFORE and AFTER exercise information is given beneath the "BEFORE" and "AFTER" columns, respectively. The "When" columns contain due dates that serve as links to chapter exercises. Scores are given in the "Won", "Sum", and "Done" columns. When a student views a Plan Tab (as shown in Figure 1) they see their own scores. The "Won" column gives the percentage of points obtained, but only on completed problems. The "Sum" column gives the total number of points the student obtained on all problems as wells as the maximum possible points. The "Done" column is used to show the number of problems completed by the student, as well as the total number of problems.

Students use the Plan Tab to plan ahead by looking at a chapter's due date(s), number of problems, and total points. Not only do they see when assignments are due, but they can prioritize assignments based on the maximum points and number of problems.

When an instructor views the Plan Tab for a given section, the scores are summary statistics. The average percent points, average points obtained, and average number of problems completed are given for an entire section. The instructor can see in real time the progress of the class as it completes problems and evaluate the section's performance once the due date passes. Poor scores can be addressed by reviewing the chapter in class. The instructor can also view the section's performance on individual exercise, at the bank and sub-bank level. Finally, the instructor can access each student's performance on individual exercises, individual chapters, and overall.

Clicking on a link in the Chapter column of the Plan Tab takes the student to the Read Tab where the selected chapter is displayed (Figure 2). Students navigate a chapter by scrolling or use navigation menus for headings, figures, tables, equation, and examples. Only heading and figure navigation is included in the chapter shown in Figure 2 because the chapter has no tables,

equations, or examples. Hyperlinks can take students to related content: in their ebook; outside their ebook but in the PathFinder database; or outside the PathFinder database, i.e., on the internet.

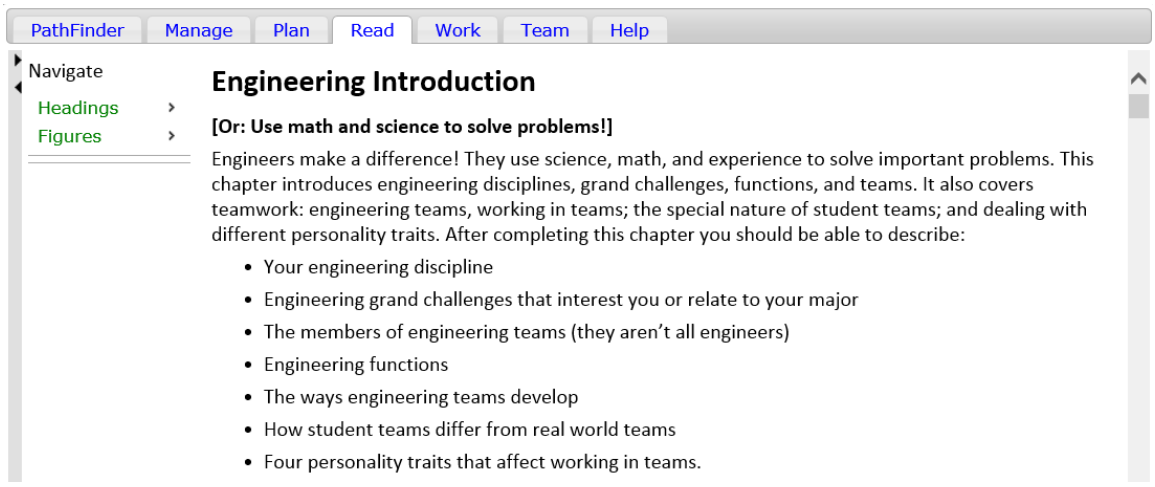

Figure 2: PathFinder Ebook Chapter

PathFinder ebooks include multiple choice and calculation exercises.[19] The ebook described here contains 757 exercises in 150 banks. BEFORE exercises were grouped into 86 banks. AFTER exercises were grouped into 64 banks. Each bank was used to select one problem for a given student; thus, each student completed 150 online questions.

The multiple choice problem shown in Figure 3 is a BEFORE exercise. The "Investigate" button is used to find related content in the ebook. As shown in the Figure, the student is on the first of two attempts. The number of attempts can be varied by the ebook creator, as well as the number of points available on each attempt. For the problem shown below, 10 points are available on the first attempt, falling to 8 on the second.

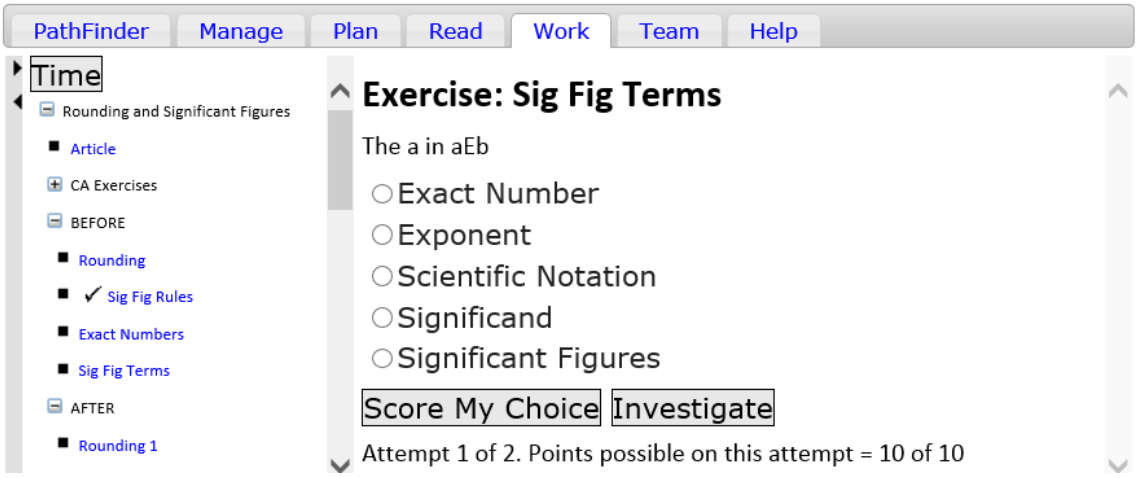

Figure 3: PathFinder Ebook Multiple Choice Exercise

The calculation problem shown in Figure 4 is an AFTER exercise. The "Practice" button can be used to access a similar or related exercise the student can complete for practice; their score on

the practice exercise is not recorded. Calculation problems can have multiple parts. As shown in the Figure, the student is on the first attempt of the first part of the problem, which has two parts total. This particular problem came from a bank of 9, each randomly assigned to students in a given section. The given information (X_1 to X_5) was randomly varied for each student, so students assigned the same problem got different given information. PathFinder uses the same MathML used to display equation 1 in Figure 4 to determine the answer to step 2.

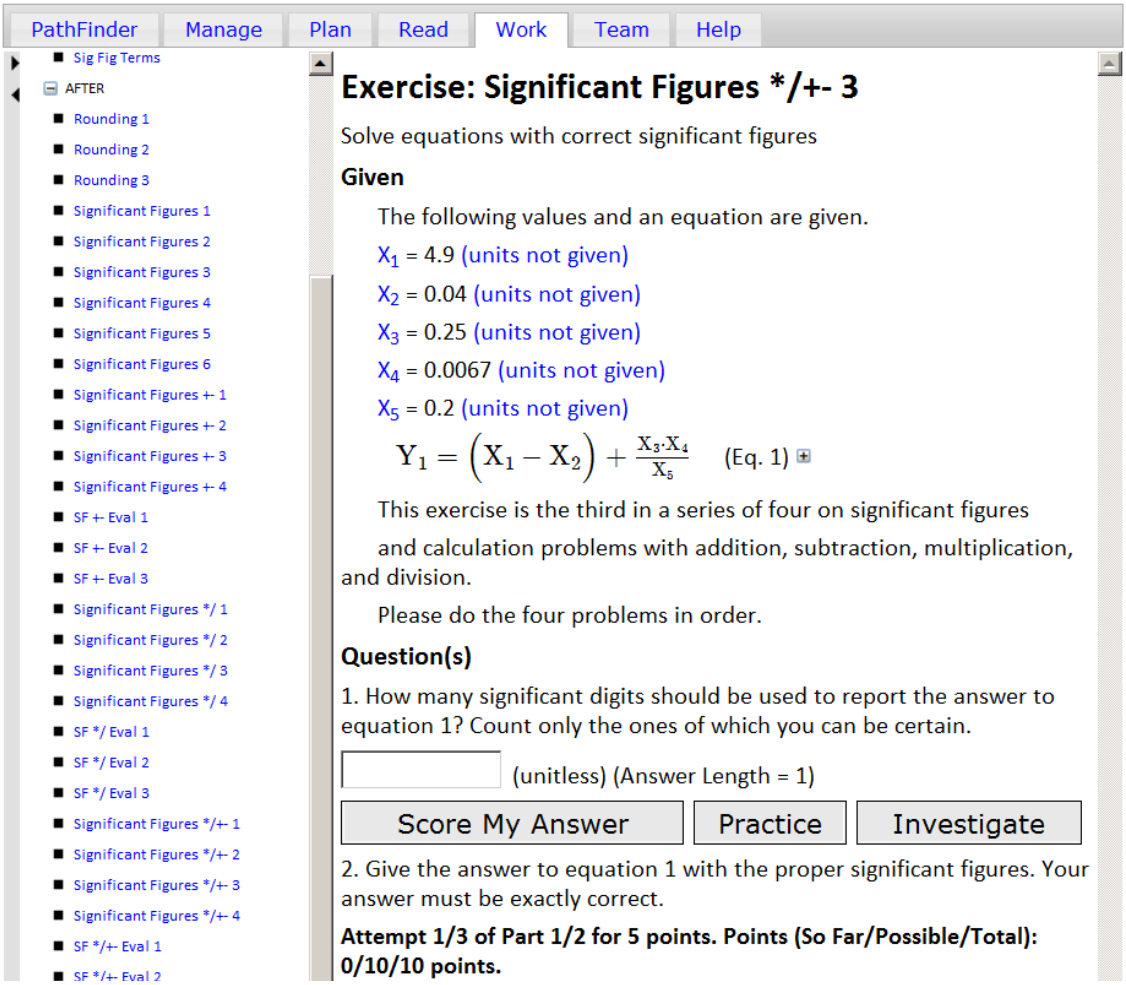

Figure 4: PathFinder EBook Calculation Exercise

Method

A survey of 12 questions with multiple parts was administered to the students via SurveyMonkey during the last two weeks of the semester. The response rate was 58 % (150 of 256 students). A second survey of 10 questions with multiple parts was administered to the teachers via SurveyMonkey during the last two weeks of the semester. All 9 teachers completed the survey (3 teachers taught more than one section).

Results and Discussion

Students

Student satisfaction with PathFinder in general is reported using Table 1. Approximately 17 % of student were unsatisfied with the Ebook price of $25. These students do not realize that most of the price of a traditional textbook is the content, not the paper. Student opinion regarding the ebook content was positive, but not overwhelmingly so. This can be improved. Only 6 % or less of the respondents were unsatisfied or very unsatisfied with the navigation features.

Table 1: Satisfaction with PathFinder General Elements (Percent of responses)

Element	Very Satisfied	Satisfied	Neutral	Unsatisfied	Very Unsatisfied	Did not Use
Ebook price ($25)	21	35	27	10	7	0%
Ebook content	12	54	21	8	3	1%
Pathfinder Navigation	40	42	12	2	3	1%
EBook Navigation	42.7	38.9	12.2	1.5	3.1	1.5

The success of any hybrid course depends on easy and fast internet connectivity (Table 2). Some universities struggle to keep up with expanding student bandwidth demand. Careful consideration of connection resources should be made before converting too many courses to hybrid status. Encouraging students to use wired connections when possible may help somewhat; however, even the wired connections left more than a quarter of students either neutral or dissatisfied.

Table 2: Satisfaction with Internet Connections in Dorms (Percent of responses)

Connection to Internet	Very Satisfied	Satisfied	Neutral	Unsatisfied	Very Unsatisfied	Did not Use
WIRELESS network speed in Dorms	5	23	19	13	30	10
WIRED network speed in Dorms	14	25	18	7	11	25

As intended, most students accessed the PathFinder ebook using a laptop (Table 3). Tablet use was low, probably due to lower ownership levels. Smart phone access was higher than expected. PathFinder is not yet configured for Smart phone viewing. This should be addressed as soon as possible.

Table 3: Platform used by student to Access PathFinder (Percent of responses)

Platform	Very Satisfied	Satisfied	Neutral	Unsatisfied	Very Unsatisfied	Did not Use
Accessing PathFinder using a laptop	28	47	14	5	5	1
Accessing PathFinder using a desktop computer	16	31	9	3	3	39
Accessing PathFinder using a tablet	7	17	9	1	2	64
Accessing PathFinder using a smart phone	7	20	12	4	3	53

Making readings and exercises online creates opportunities would be difficult to provide with traditional course delivery. More than 83 % of respondents agreed or somewhat agreed that they were satisfied with the online due date and score display, immediate feedback, and multiple tries at each exercise part (Table 4). Fewer than 5 % disagreed or somewhat disagreed. More than 75 % agreed or somewhat agreed that they were satisfied with completing exercises in parts. Less than 8 % disagreed or somewhat disagreed.

Table 4: Student Satisfaction with PathFinder Exercise Characteristics (Percent of responses)

EBook Reading	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree
Due dates displayed on Plan Tab	46%	39%	12%	1%	3%
Scores displayed on Plan Tab	45%	46%	7%	2%	1%
Completing exercises in parts	33%	41%	17%	6%	2%
Immediate feedback on answers	51%	32%	12%	3%	2%
Multiple tries at submitting correct answer	52%	32%	10%	3%	3%

The most common motivation for reading the ebook was getting a good grade on the BEFORE problems, with 67% agreement (Table 5). Over 60 % of students also indicated that instructor expectation was a motivation to read. It is encouraging that more than half of the students appear to have been willing to enter into an informal contract to read the ebook. The teachers gave course credit in the form of the BEFORE exercises and students read the ebook in return. Only 35% felt the need to read the chapter to be able to keep up in class. Some students may have covered the material in high school or were in sections where the instructor repeated ebook materials. A few of the chapters were not challenging, e.g., PathFinder, RU Introduction, Academic Success. Finally, some chapters may not have been covered in class, e.g., the RU Introduction chapter.

Table 5: Student Reasons for Reading the Ebook (Percent of responses)

Reason to Read Ebook	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree
Good scores on BEFORE problems	32%	35%	17%	7%	9%
Something they were expected to do	25%	36%	20%	7%	12%
Avoid feeling lost in class	8%	27%	35%	11%	19%

The goal of any flipped course is for students to carefully view the preparation material before class. For the flipped course described here, the main mechanism for encouraging this was the automatically graded online BEFORE exercises. BEFORE exercises should be challenging; thus, encouraging students to carefully read the ebook to get a good score. It appears that the typical student carefully read less than half of the ebook chapters when preparing to complete the BEFORE questions (Figure 5). Chapters do not sum to 11 as each entry is an average of the results reported by all students.

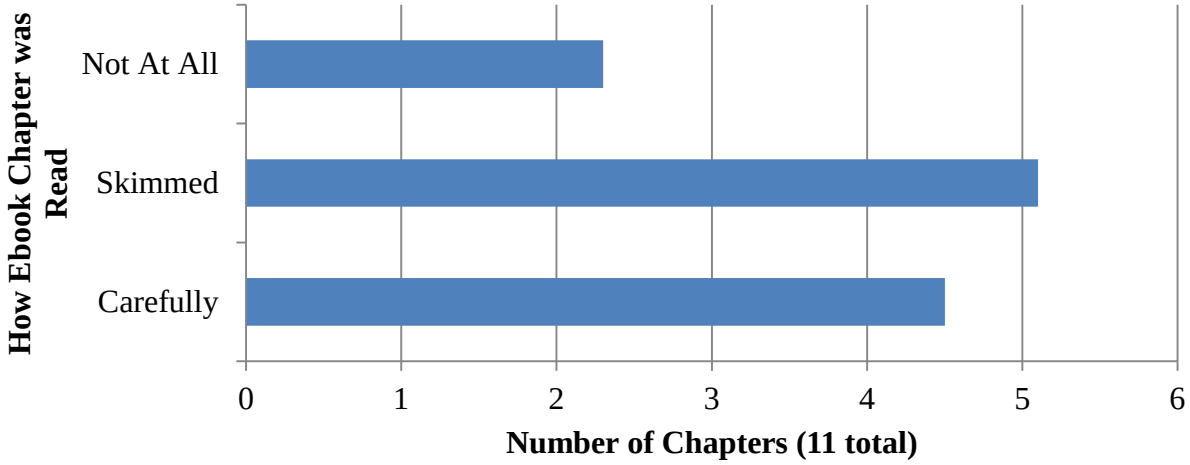

Figure 5: How Students Read the Ebook to Prepare for BEFORE Questions

On average, students report completing more than 50 % of the BEFORE questions using memory or a mix of memory and searching (Figure 6). Students able to use memory either learned the material in high school or read the ebook carefully. Students report that they completed approximately 50 % of the questions solely by searching the ebook. Searching the ebook to answer the BEFORE questions is expected to result in some preparation for class, but probably not as much as a careful reading. Creating more difficult BEFORE questions should result in better prepared students, by forcing them to learn the concepts more thoroughly and motivating then to read more carefully. The results reported in Table 5 and Figures 5 and 6 suggest that students should be encouraged to carefully read more chapters by making the BEFORE questions more difficult. Positive results may be enhanced by also making them worth more of the course Grade.

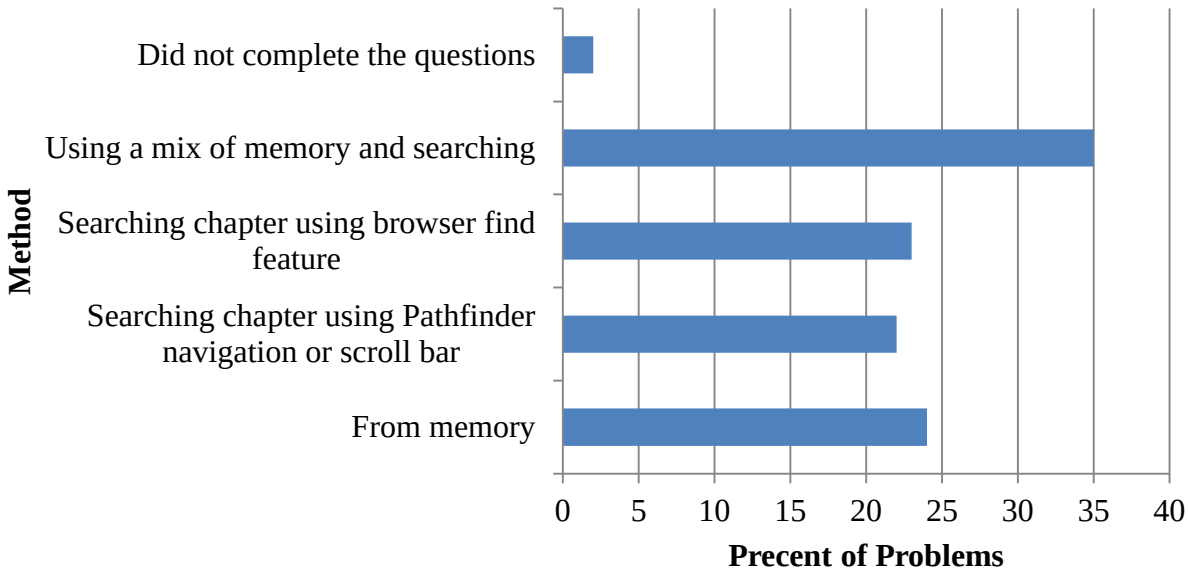

Figure 6: How BEFORE questions were Answered

Figure 7 is used to further explore the relationship between ebook reading and student preparation for class. More than 55 % of students report never feeling they had to read the chapter carefully in order to be able to successfully participate in class. Inspection of Table 5 and Figure 7 suggests that future teachers should rely more on active learning; no teacher should simply rehashing ebook readings.

AFTER exercises give students an opportunity to strengthen skills obtained from reading the ebook and participating in in-class activities. They are also used by instructors to grade students based on demonstrated progress. The most common information source students used to complete AFTER exercises was equations in the ebook (Figure 8). The percentages do not add to 100 as each is an average of the results reported by all students. Practice problems were the second most common information source, but ebook examples, high school experience, and class notes were also important. Practice problems are made possible by the hybrid nature of the course. Students simply select the Practice button when confronted with a difficult problem to access a practice problem they can work on which is not scored. For more information on practice problems, see another paper presented at this conference.[20]

Teacher Results

The hybrid flipped course was also evaluated by soliciting the opinions of the teachers. Nine people taught the 12 introduction to engineering sections: 2 professors; 4 instructors; 2 adjuncts; and 1 teaching fellow (a master's student). Five were teaching the course for the first time. Four had taught five or more times.

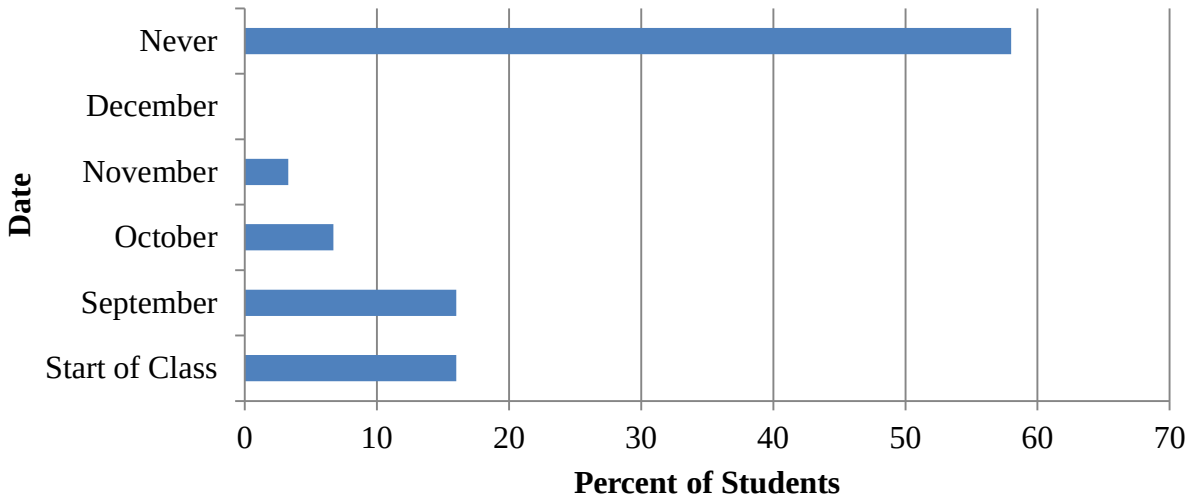

Figure 7: When Students Realized they Need to Read Ebook Carefully or be Lost in Class

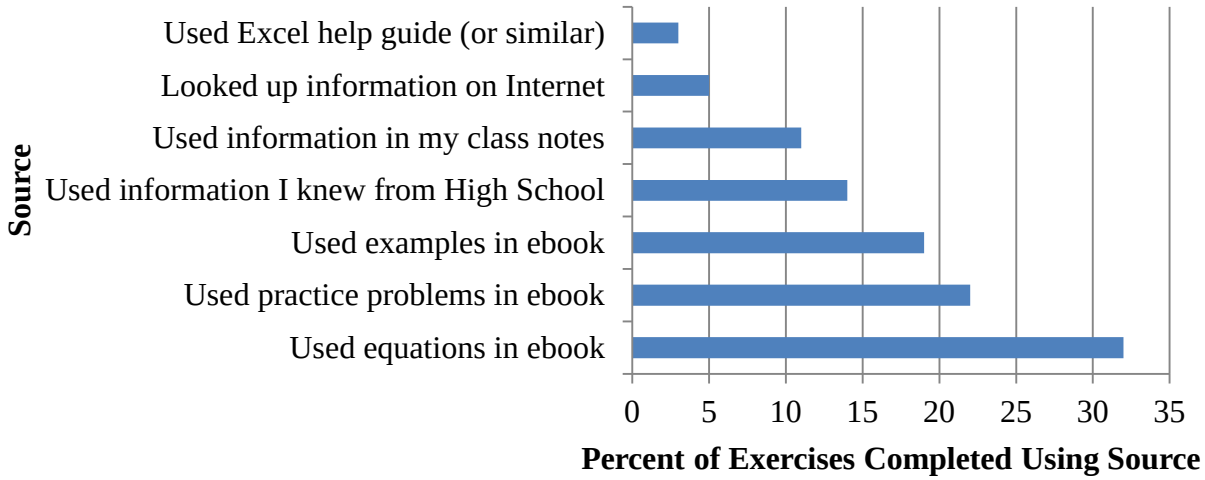

Figure 8: Information Sources used to solve AFTER Problems

Faculty were asked to appraise PathFinder in General (Tables 6). All responses were Very Good, Good, or Fair. Only one teacher rated PathFinder as overall Fair. Two gave Fair ratings to look and style and navigation. Three rated due date display and score reporting as Fair. All other ratings were Good or Very Good.

Faculty were also asked to appraise way PathFinder is used to provide online exercises (Table 7). All responses were Very Good or Good. Faculty agreed that student learning was assisted by PathFinder's ability to provide multiple attempts, immediate feedback concerning answers, stepwise completing of calculation exercises, practice exercises, and fair scoring.

Table 6: Teacher Appraisal of PathFinder in General

PathFinder Element	Very Good	Good	Fair	Poor	Very Poor
Overall	4	4	1	0	0
Look and style	3	4	2	0	0
Due date display	4	2	3	0	0
General score reporting	3	3	3	0	0
Ebook content	4	5	0	0	0
Ebook navigation	4	3	2	0	0

Table 7: Teacher Appraisal of PathFinder Exercises as a Pedagogical tool

PathFinder Problems	Very Good	Good	Fair	Poor	Very Poor
Overall	5	4	0	0	0
Student able to make multiple attempts	8	1	0	0	0
Student gets immediate feedback	8	1	0	0	0
Students complete one part at a time	5	4	0	0	0
Practice exercises	6	2	0	0	0
Scoring Fairness	5	4	0	0	0

Teachers were satisfied with the PathFinder controls (Table 8). They could use PathFinder to cut and paste students' online scores into Excel grade sheets, review a student's progress on any online problem, see solutions for all problems in the exercises banks, change online due dates, and reset problems. There were a few neutral and unsatisfied teachers; it may be possible to add or modify features for the unsatisfied few.

Table 8: Teacher Satisfaction with PathFinder Controls

Control	Very Satisfied	Satisfied	Neutral	Unsatisfied	Very Unsatisfied	Did not Use
Transferring scores to Excel	6	2	0	1	0	0
Reviewing student activity on specific exercises	5	3	1	0	0	0
Reviewing solutions	5	3	1	0	0	0
Changing due dates	5	3	0	1	0	0
Resetting problems	4	2	1	1	0	2

Nearly all of the instructors believed that PathFinder saved them time and increased their opportunities to employ active learning in the classroom (Table 9). The one teacher that did not believe that PathFinder saved time preparing lectures may have taught the course multiple times, in which case they would not have needed to prepare lectures. The same situation could also explain the one teacher that disagreed that PathFinder made it possible to do more active-learning in class.

Table 9: Teacher Perceived Benefits of PathFinder (Number of Teachers)

Element	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Saved time in general	6	2	1	0	0
Saved time creating homework	6	2	1	0	0
Saved time grading	6	3	0	0	0
Saved time preparing lectures	4	3	1	1	0
Made it possible to do more Active-Learning in class	6	2	0	1	0

One goal of a flipped course is to create more opportunities for active learning in class (Table 10). The first two chapters of the course were covered by traditional lecture during the first lab period and are omitted from the Table. The most common technique employed was still lecture, a non-active learning technique.

Table 10: Active-Learning Techniques Employed for each Ebook chapter

Chapter	Nothing	Lecture	Teacher Worked Examples	Class Worked Problems	Hands-on Activity	Used Computers	Discussed Topic	Discussed Video
Academic Success	1	7	1	0	2	0	3	1
Engineering Introduction	1	7	1	0	2	0	2	2
Presenting Technical Information	0	6	4	4	2	4	2	2
Engineering Tools - Basic Software	1	5	4	2	3	5	2	0
Engineering Communication	0	6	1	0	3	2	3	3
Rounding and Significant Figures	0	4	7	8	1	0	0	0
Uncertainty	1	4	6	6	2	2	1	0
Engineering Problem Solving	0	6	4	7	2	0	2	0
Engineering Design	0	6	3	2	5	1	3	1
Sum	*4*	*51*	*31*	*29*	*22*	*14*	*18*	*9*

As shown in Table 10, the second most common technique was the teacher working problems at the board. This can be active, e.g., if students are asked to "help" the teacher complete the example. The remainder of the columns in Table 14 are used to describe the number of times active-learning techniques were used in the 12 sections. Six of the "Class Worked Problem" events employed classroom response technology, e.g., clickers or cell phones. Computer use was both in a computer lab (6) and in class with student laptops (8). Unfortunately, it is not possible to determine from the results if PathFinder resulted in more active-learning. Furthermore, while a number of active-learning techniques were employed, there is room for more. The course coordinator can work with future teachers to ensure that more active-learning techniques are used.

Conclusions

A hybrid flipped course has been used for two years in a first year engineering course. In Fall 2013 there were 12 sections of 20 – 25 students. The course is considered a "hybrid" because the textbook and a majority of the homework exercises are delivered online. The course is considered "flipped" because students are quizzed (online) on the course ebook before material is covered in class. This may provide instructors with more opportunity to use active learning techniques during class.

Students were satisfied with the general online aspects of the course, with the exception of connectivity speed. The adoption of hybrid and entirely online courses can necessitate increased wired and wireless internet capacity. As expected, the main platform used by students was the laptop. A surprising number of students used smart phones for access, even though the website is not designed for that platform.

Providing an ebook and problems online gives new options for informing students about due dates and scores, completing problems in a stepwise fashion with immediate feedback, and giving multiple opportunities to solve each part of a problem. Student satisfaction was high with these online elements.

A major goal of the flipped classroom is getting students to prepare for class. This can be done by establishing expectations, quizzes administered before class, or class activities that require preparation. PathFinder was somewhat successful at motivating preparation through the first two methods. However, 58 % of student never felt the need to read the ebook carefully to be able to participate in class. It appears that some teachers were repeating ebook topics. Future teachers will be encouraged to use class time for active-learning. This can be accomplished by developing easy to implement activities.

Teachers were satisfied with the general online aspects of the course. They believe that PathFinder has a number of elements that are good for pedagogy, such as easy access to due dates and scores, completing problems in a stepwise fashion with immediate feedback, and giving multiple opportunities to solve each part of a problem. They believe that PathFinder saved them time and made it possible to use more active learning techniques in class. They employed a number of them in Fall 2013; however, more could and should be added to future course offerings.

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