Improvements in Student Learning Experiences by Course Revitalization

Dr. Vishwas Narayan Bedekar, Middle Tennessee State University

Dr. Vishwas N. Bedekar received his Bachelor's degree in Mechanical Engineering from University of Mumbai, Bombay, India in 2002 and his Master's degree in Mechanical Engineering from University of Texas Arlington in August 2006. He was recipient of EMNSPC graduate scholarship for the year 2005 – 2006 and Deans Doctoral Fellowship 2006 – 2009. Dr. Bedekar was a Visiting Scholar Student at Virginia Polytechnic and State University from October 2008 – December 2009. After completing his degree Doctor of Philosophy in Materials Science and Engineering from University of Texas Arlington he worked at Virginia Polytechnic and State University as a Post – doctoral fellow (Jan 2010 – Dec 2010) and as a Research Assistant Professor at University of Arkansas (Jan 2011 – Jun 2013). Dr. Bedekar is currently working as an Assistant Professor in Department of Engineering Technology at the Middle Tennessee State University (MTSU). His research is related to Energy Harvesting, Magnetoelectric Materials, Structural Health Monitoring and synthesis and characterization of novel nanomaterials. Dr. Bedekar is an editorial board member of Journal of Materials Science Research and a reviewer on 10 internationally circulated journals related to materials science and mechanical engineering. He has also served on several NSF panels as a reviewer. He is currently teaching fundamental courses in materials science and mechatronics engineering at MTSU.

Dr. Ahad S. Nasab, Middle Tennessee State University

Dr. Ahad Nasab received his PhD from Georgia Institute of Technology in 1987. He then worked as a research scientist at the Center for Laser Applications of Physics Research Group of University of Tennessee Space Institute. In 1991 he joined the faculty of Middle Tennessee State University where he is currently the coordinator of the Mechatronics Engineering degree program.

Dr. Walter W. Boles, Middle Tennessee State University

Professor and Chair Department of Engineering Technology Middle Tennessee State University Murfreesboro, TN 37130

Improvements In Student Learning Experiences By Course Revitalization

Vishwas N. Bedekar, Ahad S. Nasab and Walter W. Boles

Department of Engineering Technology

Middle Tennessee State University

1301 E. Main St, Murfreesboro, TN 37132

Abstract

We implemented a hybrid flip classroom technique to enhance student learning experience. A flipped classroom technique is opposite to a traditional classroom teaching method in that lectures will be delivered online and homework is moved from home to classroom. We chose one of the foundation courses in engineering and engineering technology, ENGR 2110: Statics for modification so that this model could be expanded to other engineering courses. Our revitalized course differed from a traditional in-class and a complete online course in the following ways: (1) Lectures were summarized in 5-20 minute videos that include important concepts from the chapter/topic, one/two worked examples, and 3-4 homework/practice problems. These synopsis video lectures were made available to students in advance so that students could learn and prepare for the lectures/problem sessions. The lecture time was devoted to reciting the key concepts, working problems in class and identifying the important homework/practice problems with real world examples. The summary video helped instructors spend more time on working out the problems and examples in class. (2) The summary video could also help students who want to review the material covered in class at home and practice. Moreover, these videos were available for students who miss a class to go back and review what was covered in class and be up to speed for the next lecture. (3) The concept was different from a traditional all-online course which provided videos of full lectures online and did not provide opportunities for students to interact with the instructors and peers in class. In this method, the instructors spent more time on working problems and quizzes during normal classroom lecture times. (4) Instructors also utilized Desire to Learn (D2L) online course management tool in order to upload the videos and assigned practice problems for enhanced student learning experience. Our findings showed that this new technique of hybrid classroom/lectures helps new engineering educators to address the key challenges of modern classroom learning to keep students engaged, motivated, and interested in the subject. This hybrid model could benefit engineering educator community and can be expanded across and beyond engineering discipline.

Introduction

With recent advancements in technologies and their awareness; more and more students use smart devices to learn, engage, participate and interact. The smart technologies dominantly include smart phones and tablets. In traditional learning experience, students attend classes, take notes form the blackboard, read the textbook and work on homework. Smith et al. presented a study on classroom based pedagogical techniques to engage students in cooperative and problem based learning. [1] McTighe et al. presented a study on backward design of engineering classes for forward action. It involved identification of desired results, analysis of multiple sources of data and develop an action plan for implementing the strategy. [2] M. Besterfield-Sacre et al. focused on freshman year engineering students as it is very important for academic success and retention in the program. They also gathered data on students' attitudes and perception s about engineering and identified realistic retention strategy. [3] Bedekar et al. studied the effect of adopting student centered teaching practices to help students enhance their learning experience. The DFW grades were significantly dropped from almost 60% to 24% and 8% in the subsequent semesters. Here, D grade stands for scores between 60% to 69.9%, F grade stands for scores below 60% and W grade stands for number of students withdrawn after census date (15 to 49 days) during the duration of course. They also identified the Do's and Don'ts of teaching a freshman level introductory class. [4] In another previous study Bedekar et al. emphasized on faculty mentoring and how it helped a young faculty to learn how to teach and adapt to new generation of students to meet their expectations. Students' engagement in classroom, connecting the dots between real world and classroom learning, giving prompt feedback and dedication and empathy towards students were some of the key aspects of modern teaching and learning. [5]

Students struggle with engineering foundation courses due to a number of reasons such as (1) A prerequisite or co-requisite requirement is not met in special cases, time lag between their MATH courses and Engineering courses, and lack of practice. (2) Students lack tutoring and hands-on help with courses. (3) Students do not learn at the same pace; hence, some students need extra time to go over the concepts and work solutions for problems. (4) In a class of 30-50 students, it becomes impractical for the instructor to significantly change the pace of teaching from an average pace. (5) If students want to review the lecture, they have to rely on their class notes, self-study, or on tutors (if available). (6) An average undergraduate student takes 12-18 credits per semester and has to spend time studying for other courses. This limits student's time for adequate lecture review. We addressed all these issues by revitalizing a foundation engineering course **ENGR 2110: Statics** as a pilot program. In this study, the instructor implemented a flip classroom technique to enhance student learning experience. This study is not a result of one of the "me too's" using flip classroom technique but rather a systematic, rigorous and tailored hybrid approach of teaching to enhance students' learning experience in a fundamental engineering course. The clear differences between our study and a traditional flipped classroom approach are explained in the later part of this section. A flipped classroom technique is opposite to a traditional classroom teaching method in that lectures will be delivered online and homework is moved from home to classroom. Several researchers have presented their findings on utilizing the flip classroom technique such as Baker et al. implemented flip classroom where lectures were used for homework and application based case studies under the instructor's guidance and lectures were made available outside of classroom for students to prepare the course content. [6] Lage et al. implemented flip classroom to promote active learning opportunities in classroom by assigning reading and videos for students to study at home before coming to class. [7, 8] More recently, Love et al., used inquiry based learning to engage students at different universities in a flipped classroom. [9] Little et al. presented a literature review and provided UK based case studies for a small scale flipped classroom project and also discussed under-represented staff experience for the duration of this study. [10]

Our revitalized course differed from a traditional in-class and a complete online course in the following ways: (1) Lectures were summarized in 15-20 minute videos that included important concepts from the chapter/topic, one/two worked examples, and 3-4 homework/practice problems. These synopsis video lectures were made available to students in Fall 2015. The lecture time was devoted to reciting the key concepts, working problems in class and identifying the important homework/practice problems with real world examples. The summary video helped instructor spend more time on working out the problems and examples in class. More details are provided in the section on Preparation and Implementation of Short Videos. (2) The summary video helped students who wanted to review the material covered in class at home and practice. Also, it was available for students who might miss a class to go back and review what was covered in class and come prepared for the next lecture. Most importantly, the videos gave students the ability to learn at their own pace. Details are provided in the section on Students' feedback and comments. (3) The concept was different from a traditional all-online course which provides videos of full lectures online and does not provide opportunities for students to interact with the instructors and peers in class. As explained earlier, the summarized lecture was available before and after classroom lectures. Instructors spent more time on working problems and quizzes inside classroom lectures. (4) Instructors also utilized Desire to Learn (D2L) online course management tool in order to upload the videos and assign practice problems for enhanced student learning experience. More details are provided in the section on Preparation and Implementation of Short Videos.

The pilot phase of this study consisted of implementing the flip classroom concept to one course ENGR 2110: Statics for monitoring the progress of students to evaluate the benefits of this pilot phase. After ironing out the problems, finding solutions and evaluating the success of the pilot phase, this technique will be extended to two other courses viz. ENGR 2120: Dynamics and ENGR 3560: Mechanics of Materials (or ET 3860: Strength of Materials). Students in Mechatronic Engineering are required to take all three courses (Statics, Dynamics, and Mechanics of Materials). Students in Mechanical Engineering Technology are required to take Statics, Dynamics, and Strength of Materials. Students in Electromechanical Engineering Technology are required to take two of the three courses (Statics and Strength of Materials). Approximate number of students affected by the pilot study for Statics course was 40 for Fall 2015 semester.

Preparation and Implementation of Short Videos

The investigators explored several options for recording short videos with audio and/or visual interfaces such as using Panopto BLTI interface [11], Camtasia, AudioNote [12], Voice recorder, Video recording using camera, audio recording, SMART Board, etc. After careful consideration of all the options and available resources, it was decided to use AudioNote application to record the audio and video inputs on a notepad interface which highlighted the text/figure/drawing as the recording proceeded into the video. This was very effective in student learning as they could keep pace with the recordings. Another important advantage of recordings was that it gave students the ability to play, pause, rewind and forward the videos to enable learning at their own pace. A typical AudioNote interface is shown in Figure 1. It consists of a notepad which was used to write on using a stylus, play, stop and pause recording interface. It also had space for identifying the title of the chapter/section.

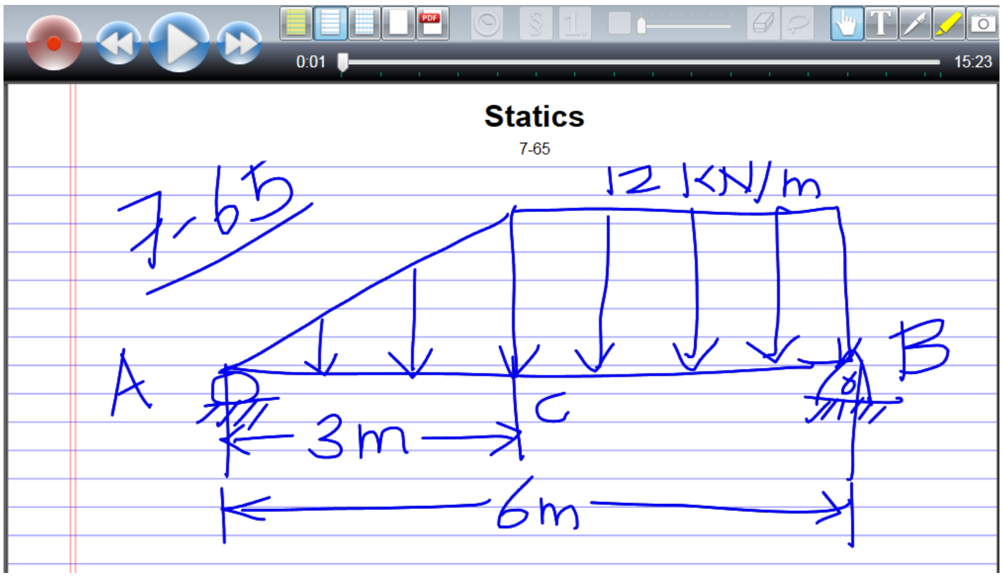

Figure 1 AudioNote application interface [11]

Initially, the instructors explored AudioNote with evaluation (free) version. However, it had limitations with regard to the number of videos, maximum duration of each video, and total duration of recordings. Hence, a full version of the application was purchased which eliminated all the aforementioned limitations. Figure 2 shows a snapshot of AudioNote interface at an instance where instructor is talking about and highlighting the support reaction at point B on the beam. The software highlights each letter, lines, dots, characters step by step so that it can be clearly seen by students. Also, students have the ability to play, pause, fast forward, rewind the video so that they can recite or revise any section of the video.

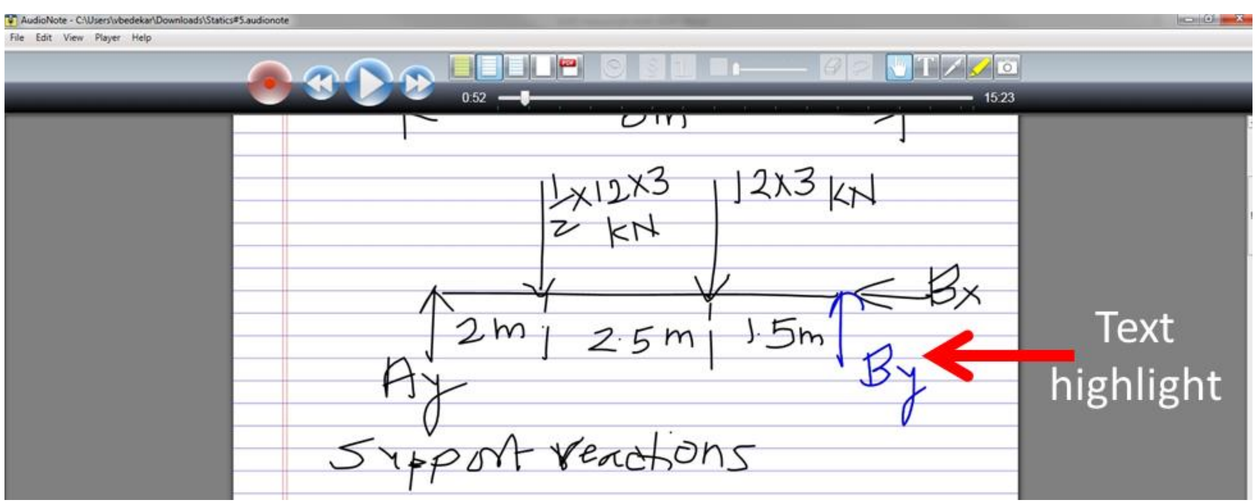

Figure 2 AudioNote Interface Highlighting Text [12]

AudioNote required a touch screen to write and record. Hence, an iPad was used to record these videos using the application platform. The AudioNote files being only accessible and visible in a compatible software, PIs had to figure out a way to re-record these videos on a Windows based platform that could be easily accessible by students. Hence, Panopto BLTI lecture recording interface was used. There are several advantages of using Panopto BLTI such as (1) It is licensed by MTSU, (2) It is an integral part of D2L online course management and can be easily added to each course with the help of software technician. (3) The recording quality of videos is very good. (4) It does provide various options to include external video and/or additional screen capture. (5) It is a secured interface for students to log in and access study materials as it is built into D2L. Figure 3 shows several features of the recording interface Panopto BLTI as available in D2L.

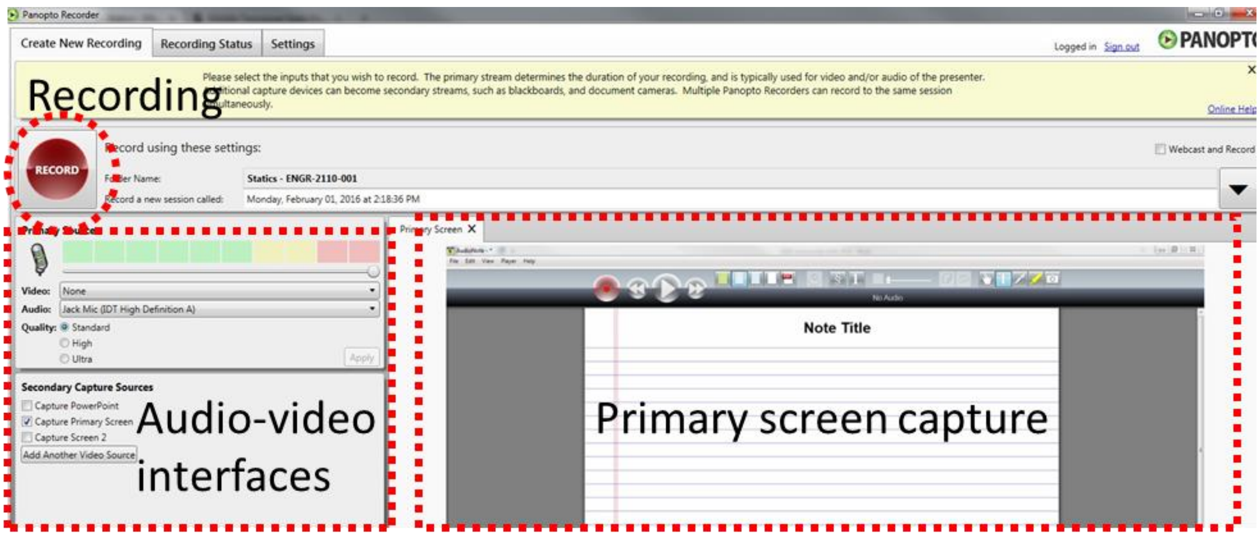

Figure 3 Panopto BLTI Recorder [11]

Figure 4 shows Panopto interface with list of recordings for ENGR 2110: Statics. Hence, with a few simple clicks, students could easily access these videos in a secured and private manner. Total of 16 videos were made available for students throughout the semester and a student feedback questionnaire was created to seek their comments as explained in the next section. Under "settings" tab, Panopto lets user chose several key features such as easy/automatic upload, availability to other users, notifications and interactions with viewers etc.

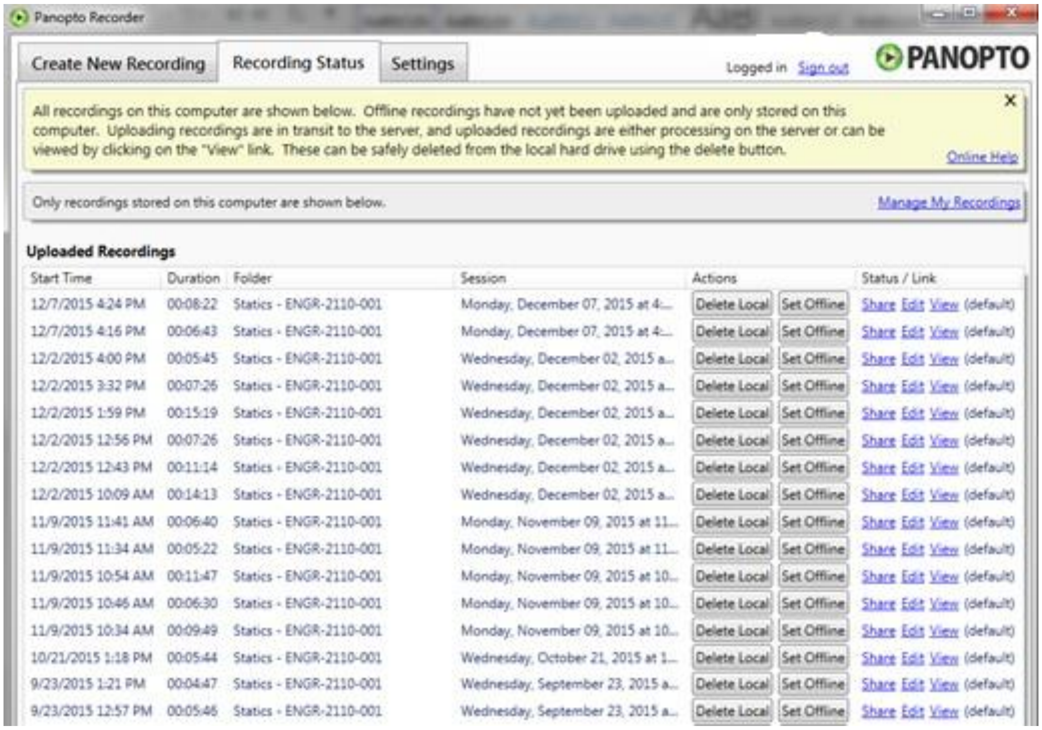

Figure 4 Recordings for ENGR 2110: Statics [11]

Results and Discussion

Student Feedback and Comments

Table 1 shows detailed student responses on the questionnaire provided to students after the final exam. It can be seen that majority of the students benefitted from watching the videos and learning at their own pace. Total of 31 students participated in the questionnaire with overwhelming positive feedback for short videos. 23 students (74%) gave rating of 4 or 5 to describe how much the videos helped them prepare for the comprehensive final. The quality of videos were reported to be good to very good by students. It was found that least 2 to 3 videos per chapter would be helpful for students to review and recite the chapter, its important concepts, solved examples etc. The fact that majority of students spent only 1 – 5 hours on watching videos reveals that this proved to be a very effective tool for students to efficiently recite the materials in the course. This helped students to manage their time well for all other courses' final exams. Several technical difficulties were encountered and resolved during the entire semester. The biggest challenge was found to be the recording time. Due to non-compatibility of windows and apple based interfaces, the instructor had to record videos on apple system and then re-record it using windows based system. This took more than double the time for recording each video. Mid-semester feedback from students was not obtained due to lack of number of videos initially uploaded on D2L. Figure 5 shows statistics obtained from D2L on number of views for uploaded videos and time in minutes spent by students viewing these videos. A total of 1014 minutes were spent by students watching the short videos. The number of views by students accessing the videos was found to be 349 times. These statistics are evident that students did access the videos for self-learning and maximum number of views just before the final exam indicated that it indeed helped students prepare better.

Table 1 Questionnaire on Short Videos reflecting Student's Feedback

Sr. No.	Question					
1	On the scale of 1 to 5; 5 being highest; how much did the uploaded videos help you prepare for the comprehensive final exam?	1	2	3	4	5
	Student Responses	**2**	**2**	**12**	**17**	**6**
2	Please rate the quality of the videos 5 being highest on a scale of 1 to 5.	1	2	3	4	5
	Student Responses	**1**	**4**	**14**	**10**	**0**
3	How many videos did you watch?	None	1-5	6-9	10-14	All 16
	Student Responses	**1**	**8**	**9**	**8**	**4**
4	How many times on average did you watch each video	None	Once	Twice	Three times	>3 times
	Student Responses	**0**	**8**	**17**	**3**	**0**
5	Given a choice, how many videos per chapter would you like to see in a course similar to statics?	One	Two	Three	Five	>5
	Student Responses	**0**	**8**	**13**	**5**	**4**
6	How many total number of hours did you spend watching the videos throughout the semester?	<1	1-5	5-10	10-15	>15
	Student Responses	**4**	**17**	**5**	**3**	**0**
7	Would you prefer a video of full lecture (1 hour 25 min) or short videos of 5-15 minute videos of solving examples?	Full videos		Short videos		
	Student Responses	**7**		**24**		
8	Did you pass Calculus-I before taking this course?	Yes		No		
	Student Responses	**31**		**0**		
9	Did you pass Physics or are currently enrolled in Physics before taking this course?	Yes		No		
	Student Responses	**29**		**2**		
10	What is your academic classification?	Freshman	Sophomore	Junior	Senior	
	Student Responses	**0**	**12**	**13**	**6**	

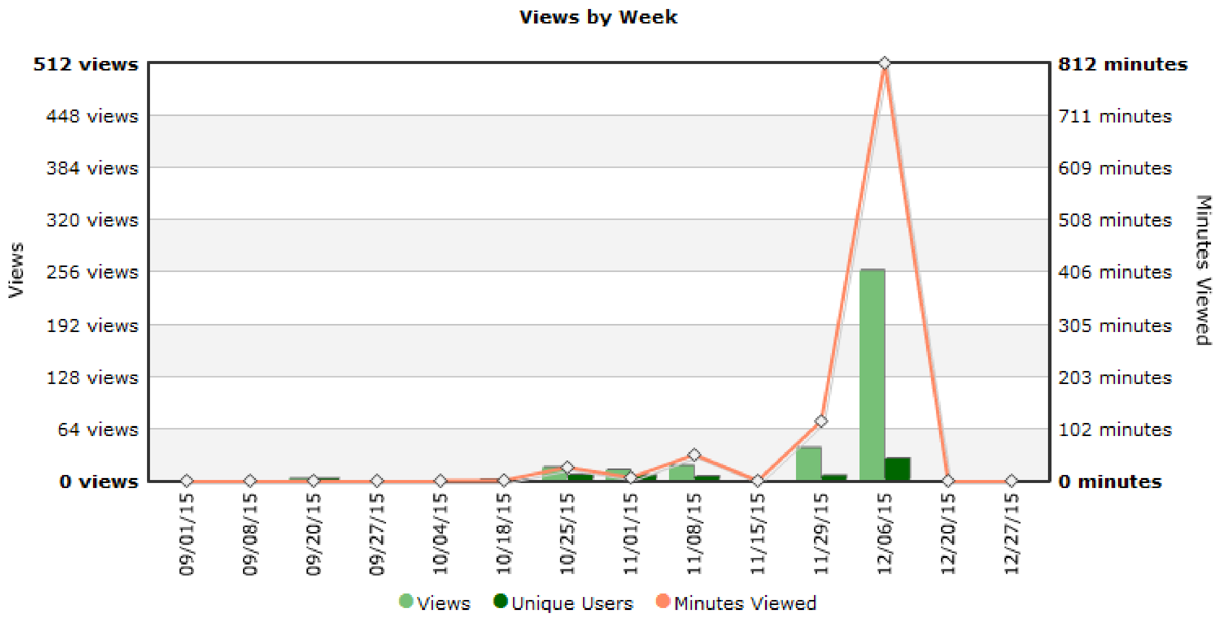

Figure 5 Statistics Of Users Accessing Short Videos In Fall 2015

Table 2 shows list of additional comments and feedback from students regarding the quality short videos and how it helped them.

Table 2: Student feedback and comments

The Good	The Bad
Overall, great learning and it really helped in class and on final	Sometimes the audio quality was poor on videos
Videos helped with preparation for final exam	Explain more about the numbers in equations
Great class, great material	This course has too much information
The videos were somewhat enjoyable	The videos are hard to get engaged in since you already have the problem fully solved
Other than couple of videos, they helped tremendously	It would have helped more if videos were available much earlier
Videos helped a lot and were similar to the educational materials I have seen in the past	To improve, I recommend a new microphone. Sound seemed to max out and crackle a bit
Content of videos was fantastic	The videos would be more of a benefit if worked out while speaking

Students' additional comments indicated that the videos helped them in the course, particularly in the comprehensive final exam. Other positive feedback included on the content of the videos and their comparison with existing educational materials. One of the challenges encountered by students was that sometimes the audio quality was poor and it was difficult to understand each word. Other constructive feedback provided by students was to use a software interface that would solve the problem in real time as the instructor speaks and not just highlight the content while the video progresses. Equations needed little more attention and explanation. Overall, the short videos helped students in this pilot study not only to prepare for the final exam but also to learn at their own pace and understand key concepts of Statics. We plan to address these challenges in the future research.

Student Evaluations for Fall 2015

Figure 6 shows student evaluations (scale 1 to 5; rescaled to compare different averages) for the instructor of ENGR 2110 for the Fall 2015 semester. Generally, the instructor is evaluated by students based on following categories: (i) Presentation Ability, (ii) Organization and Clarity, (iii) Assignment and Grading, (iv) Intellectual and Scholarly Approach, (v) Incorporation of Student Interaction, (vi) Motivating the Students and (vii) Effectiveness and Worth. The instructor matched or exceeded ratings when compared to the departmental ratings in motivation of students, assignments and grading, organization and clarity and presentation ability and more importantly Incorporation of Student Interaction. The instructor was surpassed by the college and university ratings in several categories. Although, this is true; it will not be fair comparison to generalize student ratings with traditional engineering courses and general education courses where the content and approach can be significantly different across disciplines. A more standardized approach and study can be used to compare instructor averages across the college and university. These will include performance in STEM disciplines and non-STEM disciplines. The instructor was able to effectively generate an interest in accessing the short videos amongst students and that resulted in several students doing well on the exam.

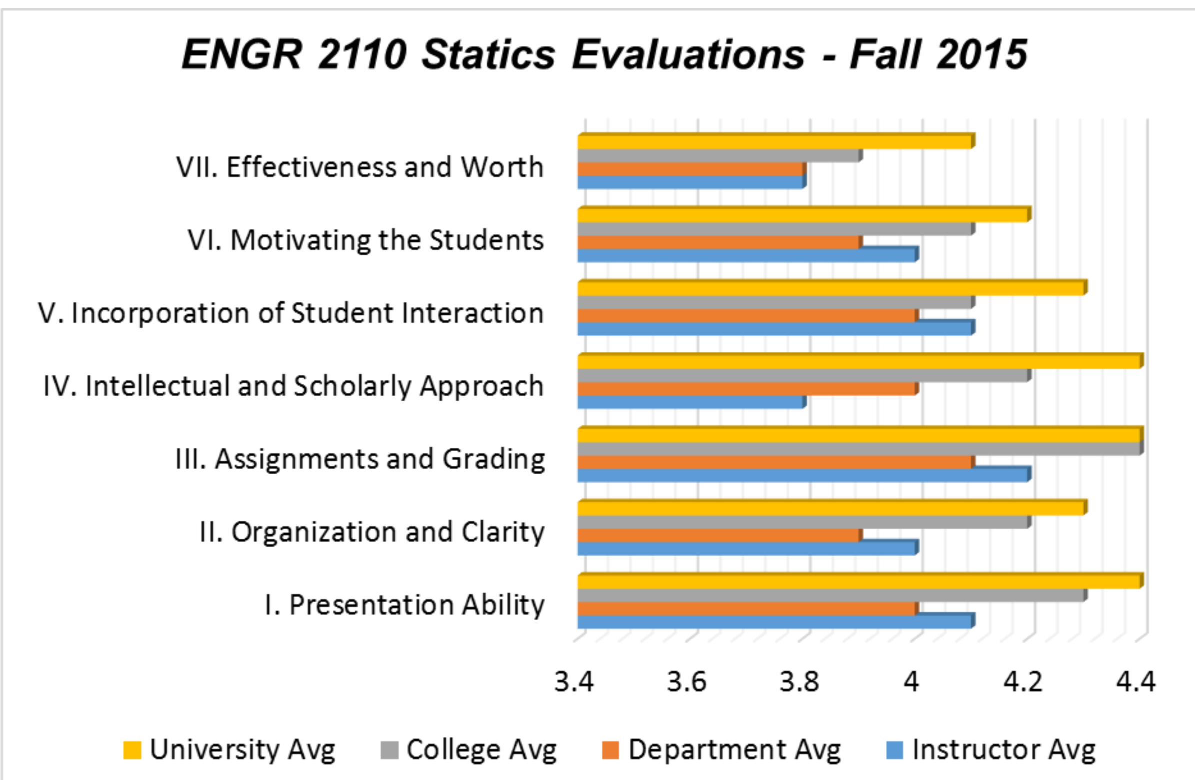

Figure 6 Student Evaluations For Fall 2015

Grade Distribution for Fall 2015

The grade distribution for ENGR 2110 taught in Fall 2015 is shown in Figure 7. Although, the ABC percentage slightly decreased from 84% for the previous academic year for this pilot study, authors believe that the quality of the videos can be improved and more videos can be made available to students in advance so that they can take full advantage of this hybrid flip classroom learning experience. Also, every semester, new students enroll in this course; hence, there cannot be a standardized percentage for attaining ABC grades.

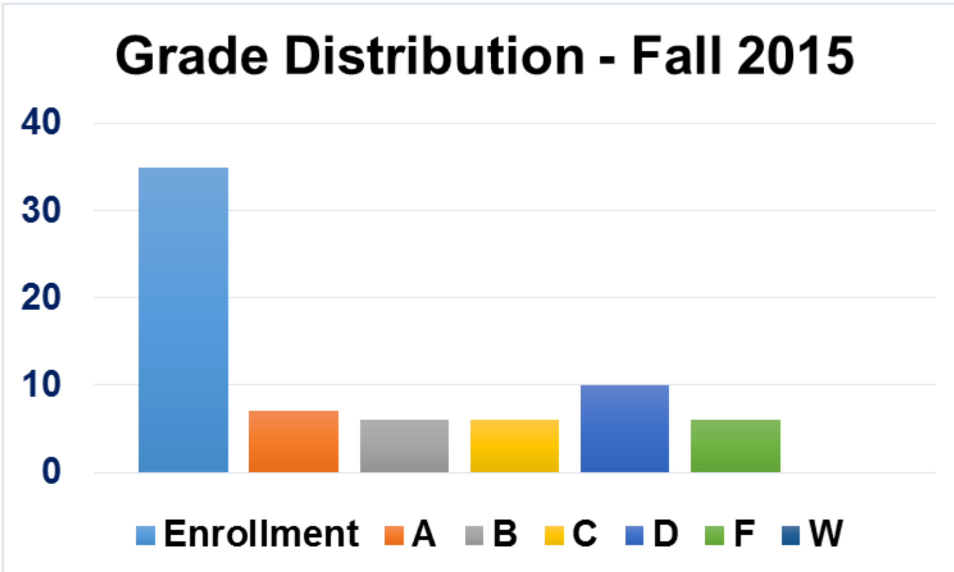

Figure 7 Grade Distribution – ENGR 2110 Statics – Fall 2015

It was clear from students' feedback that 100% of students had met their prerequisite of Calculus-I and 94.5% of students had met their co-requisite Physics-I. Majority of the students were enrolled in Statics in their sophomore or junior year and a few in the senior year. This could be improved by making sure that students meet their MATH and PHYSICS requirements in freshman year and move on to core engineering classes beginning year two. It would have been highly beneficial to the students if they pass Physics before taking statics and investigators are planning on proposing this change through the academic committees. Passing Calculus and Physics before taking Statics will prepare students better for core engineering courses such as Statics, Dynamics and Mechanics of Materials. This study emphasizes that a hybrid approach of flipped classroom can fundamentally help students learn the subject better at their own pace. This study also showed statistical evidence that students who watched the short videos did better in the final exam of the course compared to students who did not spend much time on Panopto and was further corroborated by D2L statistics. Authors also would like to highlight several challenges to flip a classroom using hybrid approach such as quality of the audio and video, necessity of early availability of the videos and narrating the solution in-situ while actually solving the problem using a software interface. Our study provides a baseline for new engineering educators who are interested in making classrooms more engaging and interactive. Also, instead of a general flipped classroom approach which requires students listen to the entire lecture which may not be as engaging as compared to the hybrid technique explained in this paper which focuses on learning key concepts and solving problems in a short duration. Authors believe that this pilot study can be implemented by new engineering educators across engineering disciplines and institutions. We also plan to build upon the findings of this study to expand it to other foundation engineering courses such as Dynamics, Mechanics of Materials and Strength of Materials.

Conclusion

In this study, we successfully implemented a flip classroom technique to a fundamental engineering course ENGR 2110: Statics, and utilized an interface that was readily available to students and instructor. A total of 16 videos were available for students through D2L interface and 74% of students benefitted to prepare well for the final exam. Students accessed the videos for a total 349 times resulting in 1014 minutes of usage. Several students applauded that they were able to study at their own pace at their convenience rather than just spending one and a half hour on lecture. This study also showed that students who watched the short videos did better than students who did not access them and this was corroborated by D2L statistical analysis. Some of the challenges found in this study were poor audio quality in some videos and software interface that did not "write" in real-time. The grade distribution did not conclusively reflect on benefit of short videos; however, to authors' best knowledge, a pilot study cannot be used to standardize grade distribution or student performances in one semester. This hybrid flip classroom model can be expanded to other fundamental engineering courses to improve the quality of teaching and enhance students' learning experiences. Authors believe that these findings can be treated as a baseline model for implementing hybrid flip classroom in engineering courses and help new engineering educators to educate students in better and efficient way using latest technology.

Acknowledgment

Authors would like to acknowledge financial support from Tennessee Board of Regents through grant # 230607.

References

1. K. A. Smith, S. D. Sheppard, D. W. Johnson and R. T. Johnson, "Pedagogies of Engagement: Classroom-Based Practices", Journal of Engineering Education, Volume 94, Issue 1, pages 87–101, January 2005.
2. G. Wiggins and J. McTighe, "Understanding by Design", Alexandria, Va.: ASCD, 1998.
3. M. Besterfield-Sacre, C. J. Atman and L. J. Shuman, "Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering", Journal of Engineering Education, Volume 86, Issue 2, pages 139–149, April 1997.
4. V. Bedekar, J. Lee, D. Spearot, A. Malshe, Learning How To Learn And Teach: Mentor And Mentee Team, American Society for Engineering Education 2013.
5. V. Bedekar, A. Nasab and W. Boles, "Improvement In Learning Experiences By Adopting Student Centered Teaching Practices", ASEE, Seattle, June 2015.
6. J. W. Baker, "The "classroom flip": Using web course management tools to become the guide by the side". 11th International Conference on College Teaching and Learning, Jacksonville, FL, 2000.
7. M. J. Lage, & G. J. Platt, "The internet and the inverted classroom", *Journal of Economic Education, 31*, 11, 2000.
8. M. J. Lage, G. J. Platt, & M. Treglia, "Inverting the classroom: A gateway to creating an inclusive learning environment", *Journal of Economic Education, 31*, 30-43, 2000.
9. B. Love , A. Hodge , C. Corritore , D. C. Ernst, "Inquiry-Based Learning and the Flipped Classroom Model", PRIMUS, Vol. 25, Iss. 8, 2015
10. C. Little, "The flipped classroom in further education: literature review and case study", Research in Post-Compulsory Education, Vol. 20, Iss. 3, 2015
11. Panopto BLTI, Copyright ©2016 Panopto, Inc.
12. AudioNote, Copyright © 2016 Luminant Software, Inc.