

”Making learning whole” with the use of pre-recorded videos for basic engineering courses

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Abstract

This research is mainly an effort to improve teaching and learning of basic engineering courses to take care of the learning needs of the students. Main courses targeted for the discussion in this paper are two undergraduate electrical engineering courses namely Circuit Analysis and Signals and Systems. Most of the students in these courses are new to the university style teaching and in addition in both these courses the course content is lengthy and complicated. This presents numerous challenges for teachers as well as students to conceptually learn the course content. The author started using pre-recorded videos for these courses before pandemic and continued using these videos during pandemic. There have been some positive reviews from students regarding the use of the videos that remained same before and during pandemic. The aim of this article is to describe the thought process of the researcher while making the videos and using them in classes and to present student’s responses to these videos. The author strongly believes that an activity like this seems to be working in better learning and teaching of these courses. The author will use David Perkin’s framework of “making learning whole” to present the case. The paper concludes with how this approach can be used to enhance learning (of technical concepts or professional skills) in many other engineering courses.

1. Introduction

Engineering profession is ever so growing and so are the curriculum needs and classroom sizes. This has been creating increasing challenges for educators in terms of completing the course and providing more learning and participation opportunities to students specially in large classes of diverse students. In addition, engineering students are now expected to learn the professional skills in addition to technical skills throughout the program. The development of such teaching and learning activities and evaluating the impact has been a continuous challenge for engineering educators for quite some time now. There is a need for engineering educators to get more creative to achieve multiple goals within limited time. This study is an attempt to explore one such idea.

2. Method

The initial motivation of making videos was to enhance teaching and learning in large classes. The videos were made mostly for the first-year courses which become pre-requisite for many other courses. A good understanding of the topics covered in these courses is not just important to satisfy the pre-requisite requirement, but is also important for the success of the student (and hence improved motivation) throughout the program. The courses initially selected are undergraduate electrical engineering courses namely, basic circuit analysis and continuous time signals and systems.

There were a few issues that needed to be taken care of. Firstly, as mentioned already, it is important for students to grasp a good understanding of the basic concepts that lead to conceptual learning of higher concepts throughout the program. Secondly, the semester duration

(thirteen weeks) is not always enough for in-detail covering of the content that is needed to be covered in the semester. Thirdly, these courses at Concordia University are offered to large classes. In a class size of 100 or more students, (i) keeping the discussion active, (ii) taking care of each student's learning style at a time when students are already adjusting to the switch of pace from college to university, and at the same time (iii) covering the curriculum presents a lot of learning as well as teaching challenges. Fourthly, the attendance in the university is not mandatory and it was observed that students prefer to miss the classes and watch online videos available to cover for the missed classes. It was observed that when students came to the class, they brought questions from the videos they watched online (as they referred to the videos themselves) and their thought processes were adjusted with the way concepts were presented in the videos. Despite many advantages of the learning resources available online, there are some downsides as well that was detrimental for student learning and motivation, for example, sometimes students were observed to be lost in class because the teaching approach in classroom did not match with the videos they were following, sometimes the terminology used in the videos they were following did not match with the terminology used in the book, etc. It is mostly hard for students in the basic courses to follow classroom teaching and YouTube videos and be able to join the dots.

To address these teaching and learning challenges, videos were made by the instructor of the course. The initial motivation that went into making the videos for the classes was: (i) How can I guide the learning of my students in the right direction so they are not confused with multiple approaches and terms for learning/ applying a certain method (ii) How can I still be connected to my students if they are not attending the classes regularly, so that whenever they miss the classes, they are not directed towards other resources, and eventually complete disconnection with classes, and most importantly (iii) How do I impart complete and thorough knowledge to my students, encourage them to participate in class discussions, and challenge their learning when there is very limited time in classroom. To encourage more meaningful discussions in classrooms, videos were made available online at least a week in advance. Students were encouraged to watch the videos before coming to the classroom so that the class can be used more for discussions and problem solving instead of teaching the topics. However, it was not mandatory for students to watch the videos before the class. That is, the idea was not to replace classroom learning or flip the class room but to (i) use the class time effectively and (ii) provide additional learning resources for deeper understanding of concepts that is not always possible in the limited class time. This means that (i) if the students have already watched the videos before coming to the class, their questions and confusions can be addressed in the class and more meaningful examples can be covered in the class, and (ii) even if the students have not watched the material before coming to the class, instead of using the class time for something that is pretty straight forward but lengthy and time-consuming (for example, derivation of a formula), the instructor could just tell the students to watch the related video for background details (instead of deriving it in the class) and use the information (for example, the formula) directly in the class for problem solving. This keeps classroom learning and teaching comprehensive. Also, the videos were considered helpful for students to stay in touch with the classes even if they were not attending the classes regularly. It was observed that (depending on various factors like mid-terms schedule etc.) in some weeks during the semester students watched the videos before coming to the classes and in some weeks they did not.

The process that went behind making the videos was as follows: (i) There was no intention of investing resources into making fancy videos. The videos were made mostly using notability app on iPad and iPad screen was recorded while the instructor is writing and explaining. Furthermore, there were no intentions of reinventing the wheel, i.e., if a related simulation, or circuit, etc. was already available online which aligned well with the topic, the resource was used directly to augment the explanation. Again screen was recorded while accessing related websites, which was used to also encourage and help students identify relevant and useful resources and also understand the differences between any terminologies or representations in the textbook and the resource available online (that is, to join the dots), (ii) Make short videos (10-15 minutes maximum) of each concept instead of a video of one lecture, so students are not cognitively overloaded, (iii) Make videos for the examples separately, so that the information is divided in pieces and students can decide on what pace they want to go, (iv) Make videos for “additional examples” separately. The author believes that it is the “additional examples” where students can be shown a bigger picture of things, can be guided to join a lot of learning dots and challenged to push their thinking. However, providing too many examples and information sometimes carries the risk of overwhelming some students based on their learning style and capacity of a student. So separate videos for the “additional examples” gives a choice to each student to decide how much and when they are ready to be challenged. Knowing the resource is there sometimes can also encourage them to just try on their own time without feeling pressured, (v) Make “good to know” videos separately. These videos mostly carry deep and fun discussions, and sometimes the “so what” of many topics covered in the course information, but this is the content without which the student can easily pass the course and fully understand the material. The idea behind these videos is mostly to keep learning fun and motivational. There is no expectation from students to watch and learn the things discussed in these and hence students have the choice to watch (or not) these on their own pace and interest.

As mentioned already, the intention of the videos was not to flip or replace the classroom but to provide effective learning opportunities for all students with varying learning styles (mainly depth of topics and pace) in large classes. In the process, the author (who is also the instructor) started getting comments from students which revealed some additional unexpected advantages of these videos. The author created post-course surveys, mostly directed towards getting feedback on: (i) students’ learning experiences of watching the videos and (ii) how the videos can further be improved. The responses from students were encouraging to see how learning was being enhanced in various ways. This prompted the author to map Perkins’s (2010) seven principles of learning objectives to: (i) measure the effectiveness of teaching using pre-recorded videos and (ii) identify the areas in teaching and learning which can further be exploited with the use of pre-recorded videos specially for large classes and first year engineering courses.

3. Results and Discussion

In this section each principle of learning is discussed one-by-one followed by the discussion on how that particular goal is already achieved (or not being achieved currently) using pre-recorded videos, the evidence, and ideas on what can further be done using pre-recorded videos to “make learning whole”.

Principle#1: *Play the whole game*

Perkins (2010) suggests that the learning is happened when the students are able to see the complete picture of things. According to him, this can mean a big picture of the overall course, or a big picture of each individual concept. He contends that the ability to see the big picture not just help students to learn better but it also keeps them motivated and curious.

On the other hand, Felder & Silverman (1988) talks about students with varying levels of sequential and global learning styles. While some students may want to start with knowing the big picture of things, others might get overwhelmed by the information. The pre-recorded videos proved to be very helpful to achieve the goal of helping each student learn through their own preferred learning style. Initially the pre-recorded videos were provided to students one week in advance and the idea was to not bombard students with everything in the course. However, in an anonymous post-course survey, a student commented that he/she would have made better use of the pre-recorded videos if all videos were available at once and not week-wise. In a subsequent course, the instructor asked the students to submit their preferences if they would prefer to have access to all videos at once. More than half of the class (51 students out of 96) opted to have access all at once, 11 out of 96 students requested to not be given full access and the rest were indifferent. This is a clear evidence of helping students (specially who are global learners) learn better through pre-recorded videos. Also, the “good to know” videos (described in the Methods section) were developed to discuss a bigger picture of important topics to the students.

Principle#2: *Make the game worth playing*

Perkins (2010) suggests that even when students learn how to solve mathematical problems step by step, they often lack (i) the clarity of what that means in the bigger context and (ii) skills to apply the learned mathematical knowledge to solve the problems in unfamiliar situations. The “additional examples” set of problems in the pre-recorded videos are hitting that target well. Not just these videos facilitate a chance and extra time to discuss more sophisticated problems, they have also been very helpful to discuss the details at length. Furthermore, the luxury of students to be able to pause and go back (students verbally reported multiple times to the instructor) to revise the hard examples on their own pace and time have been very helpful. This has reduced the need for saying, “you’ll need to know it later” (Perkins, 2010, p. 9) or “you need it for the test” (Perkins, 2010, p. 9) when asked, “why are we studying this?” (Perkins, 2010, p. 9).

Principle#3: *Work on the hard parts*

Perkins (2010) explains that just doing an activity repeatedly is not enough to improve it, but there should be ways to challenge and deconstruct learning, identifying the hard concepts and then paying special attention to address the difficulties.

In the anonymous post-course surveys of the classes where the pre-recorded videos were used, students repeatedly responded that the videos helped them to work on the hard parts. For example, students were asked after two courses about what they used the videos for (a: review for test, b: review difficult material, c: make up for absence, d: review something that I did not understand in lecture, e: I never watched any video), the results were very similar in both courses

as shown in Table 1. It is important to know that the students in these two courses were not the same.

Table 1. Students' response to reasons what they watched pre-recorded videos for

	Circuit Analysis	Continuous time signals and systems	Remote course Circuit Analysis
Review for test	29.41%	45%	53.49%
Review difficult material	47.06%	45%	74.42%
Make up for absence	29.41%	30%	32.56%
Review something that I did not understand in lecture	52.94%	55%	18%
I never watched any video	11.76%	10%	4.65%

Additionally, in the anonymous post-course surveys, when students were asked in particular about which videos were most helpful for them, most of the students mentioned topics (like Fourier analysis, Butterworth filter design, etc.) about which there is huge evidence in the literature of being the most challenging topics.

Principle#4: *Play out of town*

To play out of town, Perkins (2010) suggests that the learning is made “whole” when the learners are able to transfer learning between various aspects of a problem. The quip used to explain the problem is: “It’s as though walking across the hall from the math room to the science room, the students forget their math” (Perkins, 2010, p. 12). Many times the opposite is true in engineering classes. Students learn to apply mathematical formulas and get an answer by following a set of steps but the ability to connect math and science is seriously lacking. A study was conducted on undergraduate electrical engineering students where they were asked to describe the concept of convolution. Majority of the students described the concept in the form of mathematical steps to solve the convolution related problem and not in terms of what the concept is (Fayyaz, 2014). The “good to know” and “additional examples” videos have been helpful in prompting students to play out of town and join the dots between mathematics, intuition, and science. Moreover, the students are elaborated on different versions of the same formulas or terms used by different authors or instructors in textbooks or YouTube etc. videos so that their playing out of town can be solidified. In the future, more sophisticated videos can be made for the harder to understand or more complicated concepts (as per the (i) evidence in the literature or (ii) by careful collection of questions asked by students in the classroom) with simulations in which students can also change the values of various parameters in the problems and understand the changes in the response of the systems due to changing parameters.

Principle#5: *Uncover the hidden game*

Perkins (2010) explains that although a game like baseball does not have an apparent relation with mathematics, but smart strategies come up when mathematical analysis is applied in the game. That is mathematics becomes a hidden game to win the game of baseball. He contends that to make a student’s learning whole, it is very important to teach the hidden games of the concepts to them. A lot of times, in the set classroom setting with set curriculum to be covered in the given amount of time with a standard kind of exam due to various constraints, it becomes a challenge for educators to provide cognitive apprenticeship to students. The concept of pre-

recorded videos to augment learning from all angles has shown some improvements in students' grades. Students have reported informally that they found advanced courses (that follow the courses where pre-recorded videos were used) very straight forward to understand. The formal data is not yet collected to measure the exact impact.

Principle#6: *Learn from the team*

Perkins (2010) contends that nothing can be achieved solo and to make learning complete, the learner must find ways to learn from the team. The pre-recorded videos are not used directly for team-work as such, however, students are provided an online forum (in the form of Google doc as it is very easy to post pictures and screen shots as well on a Google doc) to ask questions and participate in discussions related to the videos. It is not mandatory for them to participate in discussion and post questions, but they are encouraged. This forum is used in three semesters already and it stays very active. It is easy for students to pose the question on the Discussion doc at any convenient time when they are watching the videos or reflecting on it. Then other students and instructor comment and discuss.

In classroom settings, there is always limited time and everyone's learning style and speed is different. Because of these very important differences, it is never possible for all students to follow the class discussion in a more effective and useful way, and also to participate. With the use of discussion docs, they can see the questions posted on their own time and they can join the conversation in their own time, if needed, they can also go back to consult the video again to follow the discussion, which provides an opportunity to all students to learn from each other at their own pace. Furthermore, this Discussion Doc has been very helpful for the instructor to plan the classroom discussion.

This way, although no team work is involved in the pre-recorded videos, students are getting a chance to learn from each other through the discussion doc available online as well. The details of the student activity on these shared Docs are not measured formally yet though.

Principle#7: *Learning the game of learning*

According to Perkins (2010) nothing is more important in learning than learning to learn. These pre-recorded videos have definitely shown some promise in helping students learn to learn on their own and on their own time. Students are provided with a variety of resources like pre-recorded videos (of all varying complexity), discussion documents, books, etc. and throughout the term they learn how to use the resources in the way it best serves their learning needs. Students comments in anonymous post-course survey supports that as well, for example "*As a student that really wanted to attend lectures, but couldnt due to the numerous night shifts he had to do at work, I was grateful to see that the teacher posted lots of self-made content online that was extremely useful in studying this course*" and "*allow students to see all pre-recorded lectures to be able to get ahead if they would like. That way they can dedicate more time to material they find difficult*".

4. How this pre-recorded video approach of teaching to make learning whole can be exploited to enhance teaching professional skills in many technical engineering courses

In capstone design course, some interesting videos (related to social and entrepreneurial impact of engineering design) were posted on the course Moodle page without asking students to watch them. It was observed through Moodle statistics that the videos were accessed by more than 80% of the teams and some videos were viewed multiple times by one student. This is an evidence that (pre-)recorded videos can be used to prompt and encourage students to learn and explore more material (which sometimes is not covered in classroom settings due to time and other constraints), and hence play the whole game, on their own. This way students can learn to understand the overall societal impact of an engineering design (Principle#1), make careful decisions in their design by seeing the failure stories (Principle#2), are taught using variety of real life examples of the importance of societal impacts on the engineering design (Principle#3), learn to see beyond just math and science (Principle#4), learn about the potential pitfalls (Principle#5), *Principle#6 not being applicable at the moment*, and learn the game of learning to understand societal impact of an engineering design their own (Principle#7). There is a growing need for engineering students to understand the societal impacts of an engineering design and by simply exposing many different situations in the form of selected videos to students without forcing them or evaluating them on the “hidden games” can also add to their learning.

5. Conclusion

It is important to mention here that in an anonymous post-course survey, students were asked to comment on the length of the videos being too short, too long, or just the right length. In circuit analysis course, 82.35% and in continuous time signals and systems course, 75% of the students responded that the videos are just the right length. So, for the future work for the improvement in learning using pre-recorded videos, the length of the videos will be kept as it is at the moment.

It is also worth-mentioning that during the remote teaching throughout the pandemic, the zoom lectures were also recorded and posted online for students to be viewed later at their own time and pace. However, despite the low number of students attending the live zoom sessions, the number of views (reported on Moodle) of the pre-recorded videos have been way higher than the number of views of recorded lectures. Since the educator in the pre-recorded videos and lectures is the same, the author suspects that (a) the breakdown of the information into (i) explanation of the concept, (ii) examples, (iii) additional examples, and (iv) good to know categories, and (b) the short (hence less cognitive overload) duration of the videos might be one of the main reasons behind students choosing to watch pre-recorded short videos instead of recorded class lecture. Because the pre-recorded videos contain additional information as well, students actually spend more time learning the concept if they watch the pre-recorded videos as compared to watching the recorded zoom session. This further supports the idea behind the development of such learning activities for students.

Additional evidence of the effectiveness of the pre-recorded videos is the response of the anonymous post-course survey (basic circuit analysis course) after the fully remote semester to the question that since the teaching was non-traditional, if students feel confident in being able to apply the concepts learned in the course in advanced courses. Out of those who responded that

they were confident (which is 58.14% of the total class), 61.5% watched the pre-recorded videos each week, and out of those who responded that they were not confident (which was 37.21% of the total class), only 12% watched the pre-recorded videos each week.

The author has been involved in preparing the pre-recorded videos and using them in courses, for almost two years now. Based on the discussions done on the shared Google doc, questions asked by students in the classes and during office hours, and feedback recorded in the post-course surveys, the author has been adding more videos in the collection to add more information for students to “play the whole game”, “make the game worth playing”, understand “hidden games” and learn “hard parts”. As mentioned already, the motivation of the videos is not to flip the classroom or replace the classroom but making learning whole. The effort is ongoing and the work forward is to develop similar material for more basic courses and measure and improve student learning further.

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