Work in Progress: Using Videos for Improvement in Knowledge of Prerequisite Material

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Abstract

This work in progress paper outlines a project aimed at increasing the mastery of prerequisite material in mechanical engineering (ME) courses. One reason for the failure in an engineering course is a weak foundation of the students' prerequisite knowledge. Although students have completed the prerequisite courses, they may not have mastered or cannot recall the necessary subject matter. Even though most instructors spend at least a week of the semester on review of prerequisite material, students often times do not spend an adequate amount of time outside of class reviewing the material. This lack of perquisite knowledge leads them to start learning new material on a weak foundation. As the semester progresses and the material builds, these students are more likely to fall further behind, which can place them in jeopardy of failing the class.

This project seeks to improve students' recall and mastery of prerequisite knowledge and ultimately decrease failure rates, by creating an accessible library of short videos on various ME prerequisite topics. The review videos are currently being implemented in 3 ME courses (1 required undergraduate course, 1 undergraduate technical elective, and 1 graduate level course) in Spring 2019 at California State University, Fullerton. Preliminary results, including view counts and view duration, from the first week of the semester are presented. Students' learning will be assessed through direct and indirect assessment at the end of the semester in May 2019. Additionally, the futures phases of the project are outlined.

Introduction

As most engineering programs have necessary prerequisite structures, one of the most common delays in graduation is from failure (and sometimes repeated failure) of required courses. One reason for the failure in these courses, is a weak foundation of the students' prerequisite knowledge. Although students have completed the prerequisite courses, they may not have mastered or cannot recall the necessary subject matter. Even though most instructors spend at least a week of a semester (with some spending 2-3 weeks throughout the semester) on review of prerequisite material, students often times do not spend an adequate amount of time outside of class reviewing the material.

This was evident in a required, junior-level vibrations semester-long course taught by the author in Spring 2018 at California State University, Fullerton (CSUF). The 3 prerequisites to this course are (1) programming in MATLAB, (2) dynamics, and (3) a junior-level engineering analysis class. As this course brings together many topics, the first approximately 5 weeks of the course mainly consisted of going more in-depth into the prerequisite topics (for example mathematical modeling of multiple degree of freedom systems) and included only one topic that was new to most students. This was the material covered on the first midterm. After handing back the graded midterm and going over the solutions, the students were asked to think about what they believed held them back from performing better on this exam, to write out their thoughts, and turn it in anonymously in the next class. Of the 42 students in the class, 19 turned

in a response. Nine of those responses indicated that their retained knowledge from dynamics was lacking.

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Proposed solution

The field of cognitive and educational psychology has demonstrated in hundreds of papers that spacing out repeated encounters with the material over time as opposed to "cramming" leads to more learning and longer retention [1]. The optimal spacing between review of topics is a topic of current research. One method to introduce more encounters with prerequisite material is to create short review videos accessible to students via their course website.

Instructors of a senior capstone course in Civil and Environmental Engineering at Pennsylvania State University, University Park provided online modules for prerequisite topics [2]. These videos were previously created for online or flipped courses and were 90 minutes broken up into 5-20 minute segments. Their results showed that the students improved their mastery of the key concepts after watching the provided videos.

The model of a flipped classroom was the basis to create a "flipped review" for a senior-level, technical elective on bioengineering in mechanical engineering at Penn State Erie, the Behrend College [3]. The instructor removed the prerequisite review from the lecture portion of the course and replaced it with review videos and quizzes to be completed outside of the classroom. They showed through direct assessment of student work that the review videos were as effective as in-class review and through indirect assessment that the majority of students preferred the online review.

San Francisco State University has developed a series of mobile learning strategies that focus on improving student learning in a required mechanics of solids course [4]. They include recorded review videos, virtual office hours, and interactive mobile learning apps. Comparing student final grades, showed that the combination of these strategies moved C students to the A to B range. However, there is no assessment of the effectiveness of the individual strategies.

These previous studies have all been targeted at one specific course. The goal of this project is to improve students' mastery and recall of prerequisite material across all mechanical engineering (ME) courses, including undergraduate and graduate courses. To do this a "library" of short videos is being created. The topics cover any prerequisite topic from math to statics to creating a plot for a report and are identified by the ME faculty. The timeline for the project is given in Table 1.

Table 1. The timeline for the first two phases of this project.

Phase	Task	Date
1	Solicit topics from ME faculty	Completed
	Create videos	In progress
	Implement in the author's Spring 2019 courses	In progress
	Student assessment (survey)	May 2019
2	Comments from faculty	May 2019
	Update necessary videos based on faculty and student feedback	Summer 2019
	Library available for select faculty to implement	Fall 2019
	Student and faculty assessment (survey)	December 2019

Phase 1: Implementation (in progress)

The videos are created following the best practices for education videos. Following the recommendations from Vanderbilt's Center for Teaching [5], the videos

- Are brief, with the goal that the videos are under 6 minutes
- Use signaling to highlight important information (for example boxes are used to signal which equation is being used)
- Have no unnecessary information or audio
- Match modality by using step-by-step narration

The videos are currently being deployed in the author's Spring 2019 courses at CSUF, which include a required junior-level course in vibrations (32 students), a junior/senior-level technical elective in control systems (34 students), and a graduate level course in partial differential equation in ME (20 students). In phase 2 (2019/20 academic year), the library will be accessible to select instructors of ME courses at CSUF and these instructors can pick and choose which topics are applicable and post them on their course website. Students will then be able to access the topics they feel they need to refresh during the semester.

Currently, the videos are being released 2-5 days prior to when the prerequisite material is being used in class. This choice was made to avoid overwhelming the students with too many videos. Every video contains at least one example. While the previous studies [2, 3] employed a post video quiz, these videos are available for the students but they are not required to watch them or take a quiz after.

As this is the first implementation of this strategy, the author has reduced the amount of in-class review but has not eliminated it. For example, in the vibrations course in Spring 2018 three 75-minute lectures were spent reviewing ordinary differential equations (in the time and Laplace domain) versus two 75-minute lectures in Spring 2019. A goal for further implementations is to spend even less time on review of prerequisites with the possibility of eliminating certain topics from being reviewed in-class. Instead that time will be shifted to focus on applying the prerequisite knowledge to the new topic, as in [3].

The videos are created by doing a voice-over of text and figures on slides. Initially, several technologies were investigated to determine the most efficient method for delivery. It was found that writing either on slides or a whiteboard or other technology like the Learning Glass Technology [6], took a significant amount of time which increased the total length of the videos. Since the focus is on material that the students have already been taught, it was not necessary to include verbal explanation of basic steps (for example algebraic manipulations). The videos are uploaded to YouTube and a link is provided on the course websites. YouTube was chosen because of the accuracy of the automatic closed captioning.

Phase 1: Preliminary results

Eleven tenured/tenure-track ME faculty at CSUF were solicited for topics for the project. In total, 3 faculty provided topics to the author, with one providing a list of over 50 topics. Examples of the topics are given in Table 2.

Table 2. Example topics suggested by faculty

Free body diagrams
Dot operator
Cross operator
Solving linear, constant coefficient ordinary differential equations
Control volumes
Stress components
Strain components
Moments of inertia
Parallel axis-theorem
MATLAB loops
MATLAB conditional statements

With a list of over 60 topics, the author started creating videos based on the relevant prerequisites to the classes they would be teaching in Spring 2019. Six videos have been available for all 3 classes in the first week of the semester.

Students' use of the online content is being tracked using the analytics provided by YouTube. The tracking does not allow for identification of students. Primarily of interest are the number of views (and when they were watched) and how long the students watch the videos. Data was gathered from the first week after implementation using the YouTube Analytics and is given in Table 3. Note: this data has been collected before the due date of homework that makes use these topics.

Table 3. Data from the first 6 YouTube review videos released in the first week of the Spring 2019 semester.

Review Topic	Length of video (min:sec)	Number of views in first 7 days	Average view duration in first 5 days (min:sec)	Likes / Dislikes
Classification of ODEs	6:23	22	2:28	1 / 0
General time domain solution of linear constant coefficient ODEs	4:06	14	1:32	0 / 0
Time domain solution of a linear, homogeneous, constant coefficient ODEs	4:21	17	1:42	1 / 0
Time domain solution of a linear, nonhomogeneous, constant coefficient ODEs	4:53	19	2:09	1 / 0
Laplace domain solution of linear constant coefficient ODEs	3:40	12	1:51	0 / 0
Partial Fraction Expansion	8:33	16	2:57	0 / 0

Phase 1: Future work

The development and implementation of videos is ongoing. New videos will continue to be uploaded this semester. Review videos for other classes will additionally be created for the library.

Students' learning will be assessed using two metrics in May 2019. A direct assessment of the students' learning will be made from comparing the overall course grades from Spring 2018 to Spring 2019. Additionally, specific problems from the finals from Spring 2018 will be repeated on the finals for Spring 2019 for direct comparison. Indirect learning assessment will be conducted to determine students' perceptions of the review videos through an online survey posted on the course website at the end of the semester. The survey will include Likert scale questions, multiple choice questions, and free response questions. Example questions are given in Table 4. Based on the preliminary results, there will be questions directed at how to increase the amount of time spent watching the review videos.

Table 4. Sample indirect assessment questions.

Did you watch any of the review videos? If so, which ones?
How often did you access the review videos?
When during the semester did you find the review videos to be the most helpful?
Did watching the videos improve your understanding of the prerequisite material?
Do you think the review videos could replace more of the in-class review?
If you did not watch a video in its entirety the first time, why?

Phase 2: Future work

For the next phase of this project, faculty volunteers will review and provide feedback on the created videos. Their assessment along with the comments from the student surveys will be used to identify any videos that need to be updated or created. Changes to the videos will be made prior to giving select ME instructors access to the library of videos for the Fall 2019 semester. These instructors will be able to choose which videos are applicable to their course. They will be given the choice to post all of the videos at the beginning of the semester or to release them throughout the semester when they deem it is appropriate.

Students' learning will be directly and indirectly assessed following the same formats used in May 2019, though questions on the student survey may change slightly. Additionally, the failure rates and repeatable grades (C- or below) in the implemented classes will be compared to historical data for the same courses.

Beyond phase 2 future work

Based on the student feedback from phase 2, the developed videos may be updated and new videos may be created. The next round of implementation will extend the library to all of the ME instructors. Further goals of this research are to have colleagues from other departments create videos for their areas and to make the videos public, so that any instructor or student has access to the videos.

Acknowledgements

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