A Curriculum-Spanning Review Video Library to Improve Retention of Prerequisite Course Material

Dr. Hope Leigh Weiss, California State University, Fullerton

Dr. Hope L. Weiss is currently an Assistant Professor of Mechanical Engineering at California State University, Fullerton. She earned her B.S. in Mechanical and Aerospace Engineering from Cornell University, and her M.S. and Ph.D. in Mechanical Engineering from the University of California, Berkeley. Dr. Weiss' research focuses in the areas of nonlinear dynamics and chaos and engineering education. Her current research includes biomedical acoustics, active aerodynamic control systems, Tesla turbine design, and improving pre-requisite knowledge retention.

Dr. John W. Sanders, California State University, Fullerton

Dr. John W. Sanders is currently an Assistant Professor of Mechanical Engineering at California State University, Fullerton. He holds a Ph.D. and M.S. in Theoretical and Applied Mechanics from the University of Illinois at Urbana-Champaign, and a B.S. in Engineering Physics and Mathematics from Saint Louis University. His research interests include clean energy, solid mechanics, micromechanics of materials, fracture mechanics, and STEM education research.

A Curriculum-Spanning Review Video Library to Improve Retention of Prerequisite Course Material

Abstract

A weak foundation of prerequisite material can lead to poor understanding of new material and possible failure in subsequent courses. Often, students do not spend an adequate amount of time reviewing prerequisite material outside of class. In response, instructors often spend time reviewing prerequisite material during class at the expense of new topics. To address these issues, a Review Video Library (or RVL) has been created and additional videos are being added over time. The topics of the videos currently focus on prerequisite mathematics for upper-level engineering courses. While videos have long been used to teach new material and review previous material for *individual* courses, the present videos will eventually span the entire mechanical engineering curriculum, creating a unified structure that can be implemented by instructors at all levels. This paper presents a detailed assessment of the first two semesters in which the RVL has been implemented. Notably, one instructor was able to decrease the class time spent reviewing prerequisite course material by one entire 75-minute lecture during the first 5 weeks of the semester. At the same time, direct comparison of quiz grades across multiple semesters demonstrated significantly higher performance after the implementation of the RVL. Additionally, student surveys revealed that 100% of undergraduates who watched a video felt that watching the videos improved their understanding of that topic. Lessons learned during the process and ideas for future work are also presented.

Introduction

Engineering programs carefully construct their curriculum so students build upon their previously learned knowledge as they advance in their field of study. By the junior-year, there are often core courses that have 3 or more prerequisites. A recurring problem for faculty is students lacking a necessary level of knowledge from a prerequisite course. Assuming students have successfully passed the prerequisite courses, there are generally two reasons a student lacks mastery in the prerequisite knowledge:

1. They did not originally master the subject manner but earned a grade high enough to continue on to the next course
2. They cannot recall the previously learned subject matter.

The first of these two reasons can be partially addressed by requiring a minimum grade in the prerequisite courses. Generally, the most common way to address these issues is done by the instructor reviewing the prerequisite material in-class. There will still be students that should spend more time outside of class to be able to successfully master the prerequisite material necessary for their new course. Additionally, the instructor is sacrificing valuable in-class time, which could be better spent covering the new material for the course.

Proposed solution

There is a significant amount of literature about the use of videos for teaching new material. However, the goal of the present work is to increase the mastery in material that has already been

taught at least once. Several studies into using videos as a means of reviewing prerequisite material in engineering have been conducted [1, 2, 3].

Velegol et al. [3] used videos previously created for online and flipped courses for a senior capstone course (16 students) in Civil and Environmental Engineering at Pennsylvania State University, University Park. The original 90-minute videos were segmented into 5-20 minute videos. An unannounced quiz was given on day one and a second quiz (worth 3% of their final grade) was given three weeks later to directly assess the impact of the review videos. While the instructor of the course did not require the review videos to be viewed, most students watched at least one video and almost half of the students accessed all of the video content. The study found that overall the students felt that the videos were helpful in improving their prerequisite knowledge and did improve their quiz scores.

Review videos were one part of a series of mobile technologies developed and used at San Francisco State University to improve students' learning outcomes for a solid mechanics course [2]. The review videos were created specifically for the purpose of reviewing and were created using the Learning Glass technology [4]. No assessment of the individual strategies implemented was conducted but the combination of the review videos, virtual office hours, and interactive mobile learning apps was shown to lower the number of C's and D's earned and increase the number of A's and B's as compared to a previous year.

Dunsworth and Wu [1] created a "flipped review" for a senior-level, technical elective on bioengineering in mechanical engineering at Penn State Erie, the Behrend College. Five 9-11 minute review videos were created based on the five prerequisite courses. Each video had an accompanying graded quiz for a total of 7% of the course grade. In creating these videos, the authors developed a list of key features:

- Make sure the purpose of the review video is clearly communicated at the beginning of the video (i.e. the video is meant for review purposes not teaching something new)
- Use digital signaling instead of writing on the screen
- Include interactive self-check questions to keep students engaged and to segment the video
- Provide an example problem but in order to keep the video short, the solution steps were not explained in detail

These studies each focused on prerequisite review videos for one course in their curriculum. Following their successes, the goal of this project is to create online review videos to improve student's mastery and recall of prerequisite material across all mechanical engineering (ME) courses. The Review Video Library (or RVL) created is an ongoing project with videos being continuously created and updated. It has been used in select courses in Spring 2019, Fall 2019, and currently in Spring 2020. The initial timeline and preliminary results from this project are presented in [5].

Review Video Library

The topics of the videos in the RVL were initially identified by faculty. The videos are created using a voice-over of slides. Explain EDU was used on an iPad Pro to record and edit the videos. Following the best practices for education videos [6], the videos

- Are short
- Are segmented into multiple shorter videos to allow students to control of the flow of information
- Use signaling to emphasize important information
- Have no unnecessary information or audio
- Match modality by using step-by-step narration

Because the videos are being created to review previously learned material, additional attributes similar to Dunsworth and Wu's [1] key features were employed:

- The purpose of the video is clearly communicated. The following is written on the first slide of every video "Disclaimer: The intention of this video is to review a topic that you have previously learned, NOT to teach you a topic for the first time"
- At least one example problem is given at the end of every video

Generally, each video takes 2-3 hours to create the slides, record, and edit for the 3-8 minutes videos.

While previous studies [2, 3] employed a post video quiz that factored into the student's course grade to motivate students to use the videos, none of the instructors who have used the videos in their classes have done this. The videos have been made available for the students on the course website using the studied institution's Learning Management System (LMS).

Spring 2019 implementation

In Spring 2019, six prerequisite videos were implemented in three courses: a required junior-level course in vibrations, a junior/senior-level technical elective in control systems, and a graduate level course in partial differential equations in mechanical engineering, all three of which were taught by the same instructor. These courses all required previous knowledge of ordinary differential equations (ODEs), particularly solutions to linear constant coefficient ODEs. The review videos were made available on YouTube, and the titles of the videos are

- Classification of ODEs
- Solving linear, constant coefficient ODEs - Time domain
- Solving linear, constant coefficient, homogeneous ODEs - Time domain
- Solving linear, constant coefficient, nonhomogeneous ODEs - Time Domain
- Solving linear, constant coefficient ODEs - Laplace domain
- Partial Fractions Expansion

An online student survey was implemented through the courses' LMS during the last week of classes. Students were asked "Did you watch any of the YouTube review videos that were posted on the course website?" and if they indicated yes, they were asked additional questions, including "Do you feel watching the videos improved your understanding of the prerequisite material?" The overall response rate across all three classes was 71.0% with 57.3% of the

students who responded indicating that they had watched a review video. As shown in Figure 1, 100% of undergraduates who watched a video felt that watching the videos improved their understanding of that topic. This percentage was slightly lower for graduate students at 80%.

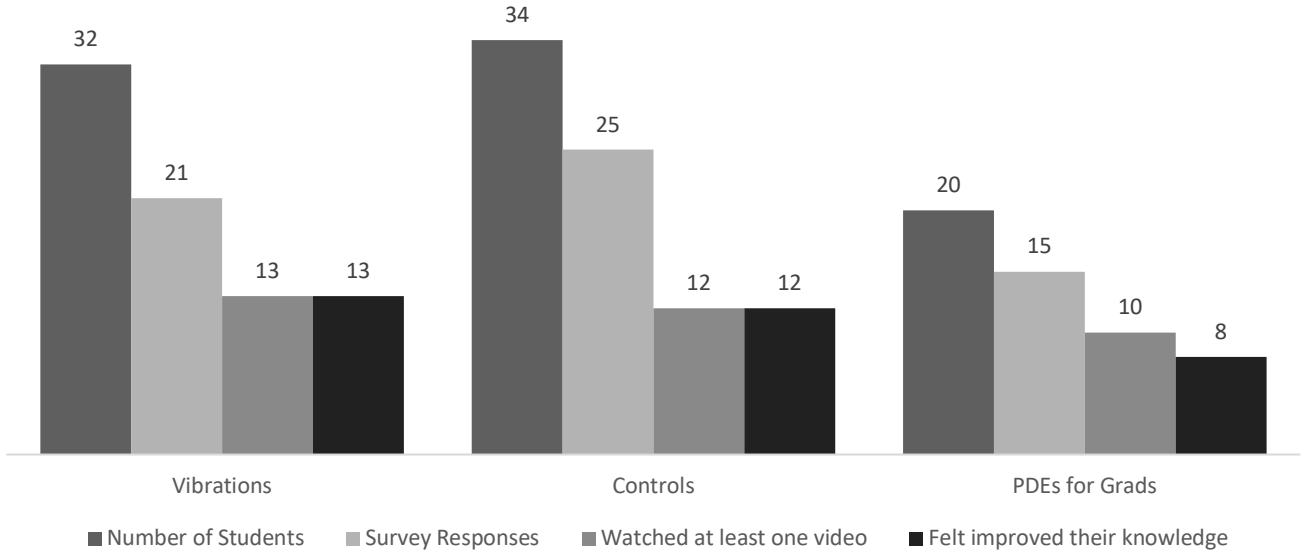

Figure 1. The total number of students and the student survey responses in Spring 2019.

Additionally, if a student indicated they had watched a video, they were asked "When during the semester did you find the review videos to be the most helpful?" and allowed to select all that applied. As seen in Figure 2, the undergraduate students in vibrations and controls found the videos more helpful when doing their homework, while the graduate students found the videos more helpful when the topic was used in class.

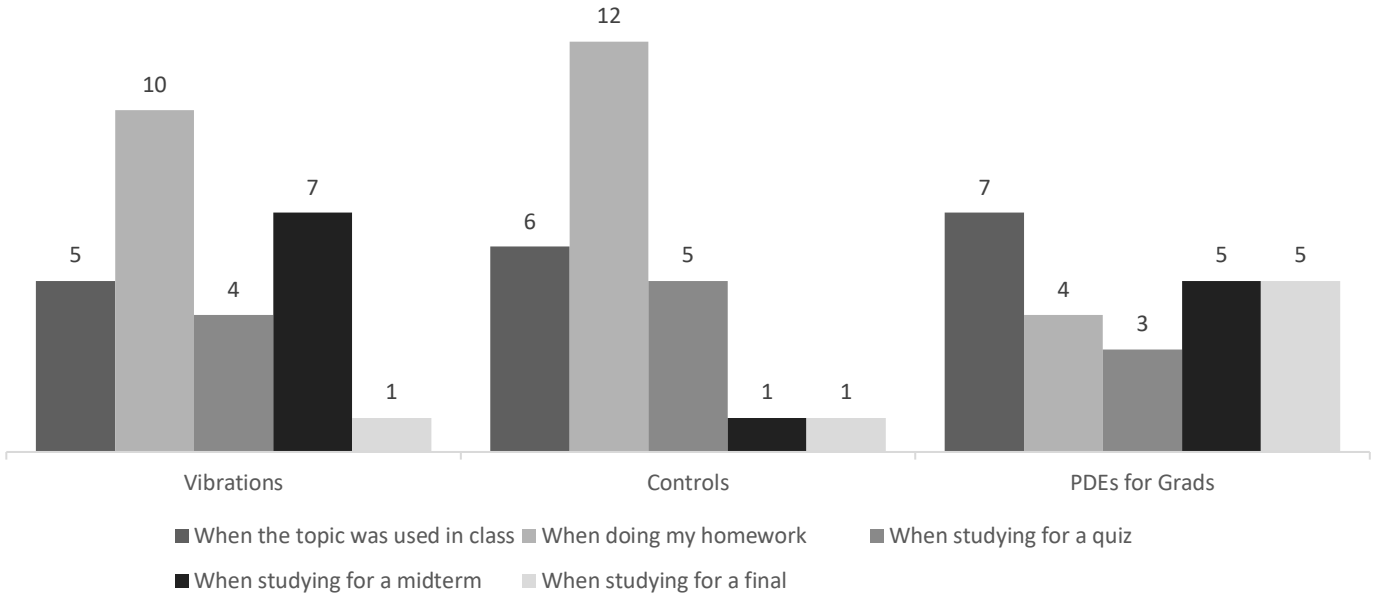

Figure 2. Student responses from Soring 2019 to “When during the semester did you find the review videos to be the most helpful?”.

From the YouTube analytics, there were 305 views in total across all six videos, for a total watch time of 10.3 hours. The average view duration ranged from 27.9% to 44.5%, meaning that not all students watched the videos in their entirety. Because of the low view duration, the free-response question “If you did not watch a video in its entirety the first time, why?” was included on the survey. Example responses included

- Having to go to work
- I realized my mistake halfway through
- I just needed a brief understanding of how to do the problem
- I was interrupted or referenced the notes as I went along the video
- I did not think Laplace transform would be used

with multiple students responding that “going to work” was the reason. The last comment listed about “not using Laplace transforms” came from a graduate student.

In an effort to encourage candid responses, the survey was completed anonymously, and no identifying information was collected through the LMS. Unfortunately, it is therefore impossible to compare the grades of students who watched the videos with those of the students who did not. However, the average grade data from Spring 2019 is presented along with historical data for the same courses and taught by the same instructor. The first quiz is a readiness assessment in both the vibrations and PDE for graduate student courses and requires the students to solve a linear constant coefficient ODE. As seen in Table 1, the Spring 2019 quiz 1 averages increased compared to past terms. Standard, one-sided t-tests were performed to determine whether the observed increase was statistically significant. In all cases, the null hypothesis was that the difference in the average quiz score between the given semester and the Spring 2019 semester was equal to zero, while the alternative hypothesis was that the Spring 2019 average was higher. The attained significance levels for the hypothesis tests were as follows: 0.00003 (Vibrations, Spring 2018), 0.007 (PDEs, Spring 2016), 0.003 (PDEs, Spring 2017), and 0.006 (PDEs, Spring 2018). The authors conclude that the performance in Spring 2019 was significantly higher than previous semesters at the 0.01-level. The average final grade for all three courses was compared to previous semesters but was found to be within the normal fluctuation of the instructor’s final course grades.

Table 1. Average quiz 1 score from several semesters all taught by the same instructor.

Course	Spring 2016	Spring 2017	Spring 2018	Spring 2019
Vibrations	--	--	72.4%	91.8%
PDEs for Grads	81.3%	79.8%	80.7%	93.1%

Students were also asked to list any topics they would like to see be made into a review video. Most of the topics suggested came from the course being taught (not a prerequisite course), but there were still some great suggestions, and these have been added to the list of future videos to make (if they were not already there). Interestingly, one student from the controls course, who specified that they had not watched any of the review videos, listed partial fractions as a topic they would like to be made into a review video. This video topic had, in fact, been posted on the

course website earlier in the semester. This student's response indicates that there could be improvement in the communication about the videos between the instructor and students.

Notably, by implementing the Review Video Library, the instructor was able to decrease the class time spent reviewing prerequisite course material in the vibrations course by one entire 75-minute lecture during the first 5 weeks of the term. This extra time allowed the instructor to add more complex examples into multiple topics: two examples of using Lagrange's equation for non-conservative systems and one example of numerically solving a nonlinear system using MATLAB's ode solvers. The instructor was also able to decrease the in-class review time in the other courses, but only by about 15 minutes which used in the same lecture to expand on a new basic topic for that class.

Fall 2019 implementation

Four additional faculty members were given access to the Review Video Library during the Fall 2019 semester. These instructors were selected based on the courses they were teaching. Three of them were teaching a required, junior-level fluid mechanics course, and two of them were teaching a junior-level engineering analysis course (one was teaching both). The PI was teaching fluid mechanics. Of the four selected faculty, only two implemented the videos in their courses. Therefore in Fall 2019, the videos were implemented in two fluid mechanics and two engineering analysis courses. It is important to note that there were more review videos relevant to the engineering analysis course available at the beginning of Fall 2019.

The survey was only given in one of the engineering analysis courses (35 students) and the survey was given on paper during the last day of class. Based on the low view rate for that term as indicated by the YouTube analytics (23 views total over all the videos), the authors added a question to the survey: "Do you remember that there are prerequisite review videos posted on the course website?" Of the students surveyed, 75% did not remember that there were review videos posted on the course website, see Figure 3. All six students who had watched at least one video felt that watching the review videos improved their understanding of the prerequisite topic.

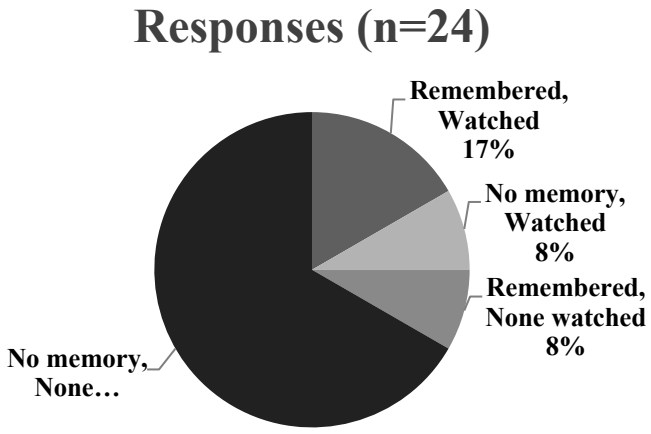

Figure 3. Student responses to "Do you remember that there are prerequisite review videos posted on the course website?" and "Did you watch any of the prerequisite videos?" from a Fall 2019 course on Engineering Analysis.

During the survey, the instructor asked students to write in any additional comments. One student wrote, “Remembered [instructor] talking about videos available but forgot about them after class.” This highlights the importance of placement of the videos on the course website. The instructor for this class had posted the links to the review videos in an “Announcement” through the course LMS system. As soon as an Announcement is posted, students receive an email with the contents of the Announcement. Announcements can also be viewed on the LMS at any later time, but this requires students to click on three links starting from the course website: first on “Announcements,” then on the individual Announcement related to the review videos, and then on the particular review video that they wish to watch. While this follows the “3-click rule”, an unofficial web design rule, it evidently is enough of a barrier that most students do not even view Announcements on the LMS system. Going forward, all instructors will be encouraged to post the links to the review videos directly onto the LMS course page, rather than in an Announcement, so that students only have to click on one link (namely, the review videos themselves).

The students were also asked to list topics that they would like to be seen made into a review video. However, most did not write anything. This is consistent with research into online versus paper evaluations of faculty that students are more likely to write lengthier comments online than on paper [7].

Spring 2020 implementation

Currently the videos are being implemented in four classes taught by the authors in Spring 2020: the same three courses as Spring 2019 (vibrations, control systems, and partial differential equations), and the same engineering analysis class from Fall 2019. Both instructors have posted the videos directly on their course website and have mentioned the videos several times in class. Data from YouTube for the first two weeks of the term has been collected. There have been 214 views with average view duration ranging from 3.5% to 69.5% and an overall percentage of 49.8% viewed. Two videos were each watched only once and for less than 15 seconds each, indicating that a student may have inadvertently clicked on that video.

The PI has been able to further reduce review time in class for the vibrations course during the first two weeks. Over four 75-minute lecture periods in vibrations the instructor was able to save an additional 15 minutes total as compared to the first implementation in Spring 2019.

During these first two weeks, the instructor has noticed that in response to “where did you see that before” or some variation of that question, multiple students have responded with “In your review video”. Similar results were found in [1].

Direct assessment will be completed in several of the courses this semester and data obtained from the LMS will be used to identify the students who have/haven’t watched the videos prior to the direct assessment, thus enabling a comparison of those two groups.

Future Work and Reflection

This is a first assessment of a Review Video Library (or RVL) intended to help students retain and master prerequisite topics across multiple courses in the mechanical engineering curriculum. We have found that all undergraduates who watched a review videos felt that they improved their knowledge in that subject. The first term of implementation by other faculty than the PI, resulted in drastically reduced views which was most likely due to placement of the videos on the course website. Direct assessment is currently taking place in the Spring 2020 term. This project is ongoing as the authors continue to create and update videos. Eventually, the library will cover prerequisite material spanning the entire mechanical engineering curriculum.

The YouTube analytics give great overall information about the usage of the videos, which can further be supplemented by individual course data from the LMS activity logs. The logs can provide the student name, when and the number of times they have clicked through the links on the website. However, this data may not capture every view, as students can go to the viewing history in YouTube to find a video that they have previously watched and students can subscribe to the YouTube channel. In the Spring 2020 semester, two students have subscribed to the channel during the first two weeks of the semester.

A more detailed analysis of the view duration over time is needed. It could be possible that students are coming back multiple times and going straight to a particular part in the video, thus decreasing the average view duration for that video. Additionally, the student perception of the videos needs to be assessed from an engagement perspective. Some questions of interest are: Does the narration of the videos need to change? Should the examples be in separate videos?

One issue with YouTube URLs has arisen during these implementations. Each YouTube video is assigned a unique URL. However, once posted, individual videos cannot be updated. If a video must be updated, the previous version must be deleted from YouTube, and the updated version posted as a new video with a different URL. In the one instance this has happened in week one of the Spring 2020 implementation, the older version was made private so that students could no longer view the video and the URL for the new video was replaced on all course websites. This is not ideal, since the URL must then be updated on all individual LMS course pages. Several solutions are being analyzed currently. One option is to create playlists of YouTube videos and link to the playlist on the course websites, since playlist URLs remain the same even if a video is added or removed.

Eventually the authors plan to make the Review Video Library available to the public, and to create an official page on the University's website similar to the video tutorial library at California Polytechnic University, Pomona [8]. Students could access all the videos, not just the ones selected by their instructors. Additionally, anyone would be able to benefit from the videos worldwide. To help students narrow down which prerequisite videos will be help for particular courses, the authors would still recommend faculty to post links on their course websites.

When the library is accessible to the entire faculty at the studied institution, instructors will be given a list of best practices for implementing these videos. From there individual instructors will be allowed to implement the videos as they deem appropriate. They will also need to

determine how much review time they feel comfortable reducing from in-class time, if any. Additionally, they can determine if they want to have a graded assignment or quiz directly tied to watching the videos.

As the authors continue to grow their library, they hope that this paper will help others create and distribute their own library of prerequisite review videos. Here are a few lessons learned during the first few implementations of the prerequisite review videos:

- The online surveys from Spring 2019 and the paper survey from Fall 2019 had roughly the same response rate, 70% compared to 68.5% respectively. In future implementations it would be better to continue the online surveys, as the analysis is much easier.
- In Spring 2019, one graduate student responded to the question about why they did not watch a video in its entirety with the response that they did not think Laplace transforms would be used. The graduate course does not go over Laplace transforms nor are they used during any part of the course. Adding videos that are unrelated to the course had a negative effect for this student. This makes sense as the point of the videos is to have them review prerequisites. If they watch a video and that topic is not used in class, they may feel that they wasted their time and that the other videos may be equally useless. In future implementations, it will be stressed to instructors that they should only post the topics related to prerequisite material for that class.
- The placement of the videos on the course website is very important. The links should be accessible directly on the main course page and the instructors should make announcements in class about their availability.

Acknowledgements

The initial work in this paper was supported by a 2018-2019 Graduation Initiative 2025 Innovation Grant from California State University, Fullerton.

References

[1] Q. Dunsworth and Y. Wu, "Effective Review of Prerequsites: Using Videos to Flip the Reviewing Process in a Senior Technical Course," in *Proceedings of 125th ASEE Annual Conference & Exposition*, Salt Lake City, Utah, 2018.

[2] Z. Jiang, A. W. Maxwell and Z. H. Merchant, "Using Mobile Learning to Improve Low Success Rate in Engineering Courses," in *Proceedings of the 125th ASEE Annual Conference & Exposition*, Salt Lake City, Utah, 2018.

[3] S. B. Velegol, S. E. Zappe and M. L. Brannon, "Online modules enable prerequisite review and mastery during design courses," in *Proceedings of the 121st ASEE Annual Conference & Exposition*, Indianapolis, IN, 2014.

[4] "Learning Glass," [Online]. Available: https://www.learning.glass/. [Accessed 3 February 2019].

[5] H. L. Weiss, "Work in Progress: Using Videos for Improvement in Knowledge of Prerequisite Material," in *Proceedings of the 126th ASEE Annual Conference & Exposition*, Tampa, Florida, 2019.

[6] C. J. Brame, "Effective educational videos," 2015. [Online]. Available: https://cft.vanderbilt.edu/guides-sub-pages/effective-educational-videos/. [Accessed 3 February 2019].

[7] D. S. Fike, D. J. Doyle and R. J. Connelly, "Online vs. Paper Evaluations of Faculty: When Less Is Just as Good," *Journal of Effective Teaching,* vol. 10, no. 2, pp. 42-54, 2010.

[8] P. M. Nissenson, N. Tsuchiya, M. Jawaharlal and A. C. Shih, "Creation of an online video tutorial library at a state university," in *2019 ASEE Annual Conference & Exposition*, Tampa, Florida, 2019.