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Video Instruction to Complement All Learning Styles in a First-Year Introduction to Engineering Course

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Abstract

This work in progress paper will evaluate the inclusion of video instruction into the laboratory sections of a first-year engineering design course. It aims to improve student performance on activity-based team projects and address strategies for adding innovative flipped classroom approaches into hands-on courses. Video instruction has the potential to combine multiple learning styles in pre-class preparation material. This video teaching methodology for laboratory instructions and assignments provides needed information to students before they attempt the labs or use equipment to expedite the learning process. A first-year engineering program initiative to incorporate more flipped classroom resources began this last summer with the help of an on-campus support center for teaching and learning. This paper will focus on aspects of short, five to ten minute, video instruction that can be used to improve performance in hands-on design projects and labs. Many video projects performed by engineering educators focus on moving in-class lectures to hours of video. In a class that is primarily activity-based, different strategies should be used to add video instruction for equipment, software, and concepts.

Introduction

The introduction to engineering course is designed to cultivate the way students majoring in engineering learn and comprehend engineering concepts. In any first-year engineering course, many assignments and activities are difficult for students because they are unfamiliar with concepts, equipment, and procedures. Some students learn better when they can visualize the kinesthetic portion of an in-class assignment. Typically, the primary resources students use to prepare for class are lab manuals and textbooks, which hopefully include some visual charts and images. However, these images are often limited by their lack of dynamic interaction. Combining read/write, aural, and visual learning styles through a video tutorial can prepare students for kinesthetic activities in class.

Video instruction can be used as a tool to offer consistent instruction to help all students start with an equal background in the material. Prior to entering the classroom some students are less inclined to understand the activity from only reading text, and these students often rely on one-on-one questions with instructors. This can be time consuming and prevent students from moving to more complex concepts. Video resources can accelerate the process of learning fundamental skills, and provide the opportunity to review basic material for students who already have experience.

Videos are an effective educational tool that amplify the learning experience for students. Used properly, multimedia instruction can gives students an opportunity to start the learning process before they step into a structured classroom or laboratory environment. This method can also easily bring experts or instructors who are in other states or countries into the classroom environment. Videos can provide the preliminary subject information to initiate the thought process for students to make the connection with prior knowledge and improve their ability to apply new concepts. Video use also has the potential to utilize students' existing knowledge base to foster their interest in engineering and provide them with techniques to assist them with information retention. Video instruction allows instructors to tap into students' prior learning or deficiencies and provide a teaching approach that helps students prepare outside of the classroom. It can provide instructors with a method to measure students' preparedness before the lab and potential for success.

For this first-year engineering course, the laboratory exercises and assignments make up three of the five weekly meeting hours. The lab assignments cover different disciplines of engineering every week, and therefore span several different topics throughout the semester. There are around 300 students each semester, and this group is broken into about 20 sections for labs. A maximum of 18 students are in each lab, and typically the assignments are performed in teams of three. Two lab teaching assistants are available for each section. This arrangement usually allows for one on one interaction throughout the lab procedure, but often prevents students from addressing more complex learning objectives. In terms of Bloom's taxonomy, the lab teaching assistants commonly address understanding and applying, rather than helping students to master analyzing and evaluating.

Literature Review

Video instruction has been a popular topic in recent engineering education research. Authors have focused on establishing curriculum suitable for video, techniques for video development, and assessment of video use. These studies will be used to provide insight into creating a video for a laboratory or design project. The fundamental difference is that these videos are not replacing lectures typically delivered during class time. Instead, they intend to reduce the amount of one on one instruction required for fundamentals of course topics.

The fundamentals of video instruction are important for addressing what aspects of the curriculum can be covered in a video and how to implement the video in the course. A rule of thumb is for the video to focus on curriculum, student involvement, and professional opportunities.[1] A wide variety of courses have transitioned to the inverted classroom, or pre-class video instruction format, including electrical engineering, architecture, statics, mechanics, software, and first-year engineering courses.[2,3,4] One concern with incorporating videos in a first-year course is that surveys have shown first-year students are more likely to watch the videos after the material was used in the course when they are not required to take a quiz.[5]

The methods of offering videos to students varies based on the course and the goals of the researchers. One study investigated the differences between three different sections – one with no videos, one with optional videos, and one with required videos.[5] In this study, it was confirmed that requiring the video increases viewership and success in the course. Another course offered either videos or slideshows as an alternative for the flipped classroom deployment.[3] A preliminary study looked at the option to distribute videos in a podcast format for students.[4]

Regardless of the distribution method, there are some rules of thumb for developing videos for use in the classroom. Several studies have emphasized four major considerations: post-quizzes, short video lengths, review of video in class, and using multimedia to make video more engaging.[6,7,8] The most critical element of these criteria for lab and project videos is to keep videos short. Some studies have shown videos less than 10 minutes in length are best,[1,8] while others have found that even shorter lengths, 5 minutes, are better for understanding information based on quiz scores.[9] Since these studies were often for videos of full lectures, the lower end of the video lengths are probably most appropriate for lab equipment or software. A detailed analysis of video lengths found that many students use YouTube speed acceleration features to limit the time spent on videos. Watching videos at less than twice the speed was found to have minimal effects on student comprehension of the information.[10]

Other established design principles of multimedia have given guidance to engineering educators creating video. Mayer's guide on multimedia defines several key principles, many of which are critical to video development for instruction. Videos should be a cohesive collection of concepts told in a logical narrative that highlights the most important concepts.[9,11] An effective video is broken into segments to organize material in an understandable format. Spoken word, pictures, and text should be combined to convey more than each could alone; in particular, the use of a real person in the video makes it easier for students to pay attention.[9,11] These techniques should all be used to create effective videos.

The assessment of flipped classroom videos usually comes from post-quizzes or surveys about the course. When including a quiz at the end of the video it is common to focus only on comprehension, not application.[1] The videos can be offered within the multimedia video or as a graded assessment online.[7] Many investigations have created surveys that are given at the end of the course to evaluate how often students viewed videos, the length of videos watched, and the usefulness of the videos to the course.[5,7] The general consensus is that viewership and usefulness of the videos increases when the length of video is relatively short, 5-10 minutes.

Method

This first-year engineering design course aims to incorporate elements of flipped classroom practices over several semesters. With the popularity of video sites such as YouTube and the heavy consumption of instructional videos on these platforms, students are starting to expect the use of this format in the education. This initial study will evaluate the effect of the first tool created, a video tutorial on integrated circuits and breadboards. A primary investigation on how the video improved students' understanding of the material was based on grades from class assignments related to the lab project using the equipment covered in the video. The frequency of use of the videos was analyzed to determine if using the video needs to be mandatory in the classroom. A before and after study determined preliminary changes in grades on assignments before the video was used in the course. At the end of the semester a brief survey question as part of the course evaluation asked if students felt the video was useful and what other topics should be added to the video instruction.

The lab assignment in the first-year engineering course which uses the video is an electronics lab focused on integrated circuits. It will be the first time many students use a breadboard, which can be confusing, especially for inexperienced, non-electrical engineering students. The video explains the basic uses of breadboards, the fundamentals of wiring, and digital logic concepts to give students a foundation for work in the lab. A few example wirings and demonstrations of inputs and outputs are discussed throughout the video. Students then use these basic wiring concepts on a more complicated schematic used to solve a problem.

The test video for this paper is a single video that is 5 minutes long. A link to the video was provided at the top of the laboratory information page. It was offered for students to use at their own discretion to prepare them for using the lab equipment. We encouraged use of the video before, during, and after the lab. The content in the video added to content currently used in the course, and it was intended to replace some of the one on one interaction with instructors on basic concepts. More videos will be developed in the future and the method of quizzing students on the material is being developed.

Analysis of Results

The video implemented in this course and the future videos that are planned are intended to provide a visual connection between concepts and the physical world. It is anticipated that the flipped classroom resources will improve students' understanding of the material, facilitate peer discussion, and allow for faster engagement in the hand-on components of the course. With the use of this more active learning approach, students will gain better understanding of the concepts and increase interest in their field of study. The video starts the learning cycle with students while the lab hands-on reinforces the learning and helps them to share their individual viewing experience with the video. The video is capable of covering extrinsic motivations, the external course requirements, by instructing students on the basic course learning objectives. Therefore, the video may allow for an in-class focus on students' intrinsic motivations, self-developed inspiration for students, to explore and discuss the advanced concepts during the hands-on portion of the lab. Future evaluation of video implementation in this course will focus on motivation factors. Increasing engagement and interactivity in the video is high on the list of enhancements for this video.

The analysis for this work in progress paper will consist of some preliminary quantitative results and qualitative recommendations for future work. In the future, a formal survey will be used to quantitatively assess the usefulness of the videos. Three primary criteria can be quantified with the data available for this study: 1) viewership, 2) grade improvements, 3) and student assessment of the video. The first-year engineering course had approximately 300 students. 236

views were tracked on the university video streaming service, and 84 views were documented on YouTube. These viewer rates are satisfactory for a first semester implementation.

The video was first incorporated into the class in the fall of 2015. Grades on the technical components of the lab reports increased from the spring of 2015 with an average of 65.2% to the fall of 2015 with an average of 73.1%. It should be noted that this difference is not based on a controlled study, but a first investigation of the preliminary data available. The number of students in the spring of 2015 and fall of 2015 was about the same around 300. The distribution of students that take the intro course in the fall and spring is random, and associated primarily with registration. These consistent factors indicate that the grade increase could reflect the use of the video, but further examination is necessary to provide any statistical significance.

In an end of semester survey, students were asked to respond yes or no if they felt that the video was useful. Out of 67 responses, 30 students said yes, and 37 students said no. A 45% approval of the video is encouraging for a first attempt at video instruction in the course.

A second question on the end of semester survey asked students what topics they thought would be beneficial for future video instruction in the course. Prior to asking this question, the faculty and on-campus support center for teaching and learning speculated about what topics would be most useful. Table 1 collects a list of topics that were suggested by faculty and teaching assistants.

Table 1: Topics Indicated by Faculty, Staff, and Teaching Assistants for Future Video Instruction

Topic	*Details*
Lab Introductions	Concepts for each lab assignment
Sensors for LEGO Mindstorms	Lab exercise and course project
Multimeter	Use in multiple lab exercises
3D Printing	3D modeling for use with a printer
Mindstorms Software	Programming for robotics
LabVIEW	Programming for lab and course projects
AutoCAD	General 3D modeling
Microsoft Project	Scheduling and Gantt chart creation
Microsoft Excel	Calculations and data presentation
Teamwork	Teamwork skills

Several of the suggested topics in Table 1 focus on software, concepts, equipment, and professional skills. There was significant overlap in the student responses compared to the faculty assumptions. Table 2 summarizes the number of students that mention a particular topic in the survey (response rate was low, and not all 67 gave suggestions).

Table 2: Number of Students that Mention a Subject in Survey for Future Video Topics

Topic	*Number of Mentions*
LabVIEW	9
Mindstorms Software	3
AutoCAD	3
Microsoft Project	2
Microsoft Excel	2
Sensors for LEGO Mindstorms	1
LEGO Digital Designer	1
3D Printing	1

The most common response for students was a desire for video instruction on LabVIEW. In addition to LabVIEW students also wanted more instruction on Mindstorms software, which is another visual programming language environment. This indicates that programming fundamentals might be an important subject to cover in future videos. Several other software including computer aided design and Microsoft office were mentioned. Students also want more information on sensors and 3D printing.

Conclusions and Recommendations

The initial use of video instruction was mostly successful considering it was not mandatory and this was the only video tutorial used for this class. Based on student responses a focus on difficult to use equipment and software are good topics to cover in future videos. The faculty speculation about important topics for future videos was similar to the desires of the students mentioned in their survey responses. This indicates that video instruction are an appropriate solution for assisting students in software and equipment used in the labs. In addition to students asking for these topics they fit into the pedagogical strategies of the course instructors.

A few comments made in person by students who viewed the video will be addressed in the future analysis of multimedia instruction in the course. One student raised a concern for non-native English speakers having difficulty understanding the spoken word in the video. Providing subtitles could improve the experience of non-native English speakers or people with difficulty hearing. YouTube functions that auto-generate subtitles can be used to make these captions with less effort. In response to this study, the university's video-sharing system, which is used for storing and tracking the videos has just launched a captioning feature. This feature allows for the transcription of a video, as well as the display and download of a caption file. Incorporating this functionality will permit instructors to improve the user experience for different types of students. This enhancement can potentially increase student engagement and completion rate of the video.

Students appreciate that a teaching assistant was used in the video rather than a professor. This visual provided a real-life example of a person close in age, in their field, and achieving in an assignment given to the students. This satisfied their intrinsic needs and increased motivation and desire to learn.

A future study of this initiative is in progress. More videos are planned for production, and they will take the findings of this preliminary assessment into consideration. A more extensive review of the video instruction and a comprehensive survey of students will provide more quantitative data to be used in video production.

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