Board 82: Work in Progress: Examination of Video Demonstrations as an Alternate Content-Delivery Method

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(WIP) Examination of Video Demonstrations as an Alternate Content Delivery Method

Introduction: Live demonstrations have long been one of the hallmarks of introductory courses in physics and chemistry. Despite their prevalence in these disciplines, live demonstrations are far less common in many introductory engineering courses. While there are a myriad of reasons that instructors may decide to forgo live demonstrations, two common reasons for doing so are that they doubt the effectiveness of live demonstrations, or that the time required to develop and implement an effective demonstration prohibits instructors from utilizing them.

As a result of the COVID-19 pandemic, instructors around the world were forced to adapt their courses to be delivered remotely. While the vast majority of classes have returned to traditional in-person formats, instructors retain the skills required to produce effective teaching videos. It has been shown that online laboratory activities can have some unique advantages [1]. This presents an opportunity for instructors to develop pre-recorded demonstration videos to reap the benefits of live demonstrations, while circumventing many of their drawbacks.

It is well established that students enjoy live demonstrations [2-3]. Furthermore, studies have shown that video demonstrations can be just as effective as live demonstrations in terms of improving student learning and enjoyment [4]. However, it has also been shown that in many scenarios students fail to learn the core concepts that instructors are trying to communicate via a demonstration [5-6]. One common cause of ineffective demonstrations is that students will make incorrect observations, which will lead to incorrect conclusions [7]. This challenge can be mitigated in a video format where instructors have additional control over the demonstration and can highlight key pieces of information. Another common issue is that students will passively observe demonstrations, without thinking about them. One excellent way to get students thinking about a demonstration is to pause them and have students predict the outcome [8-9], which can easily be done with a video-based modality.

Another major benefit of implementing demonstrations is to improve student focus and engagement. While many resources claim that students' attention spans wane after 10-15 minutes, we acknowledge that results are not backed up by rigorous scientific study [10-11]. Nevertheless, one approach that has been implemented for large courses is to forgo the traditional 50-minute lecture period and instead deliver content in smaller quantities [12].

In this work we discuss the implementation of a series of demonstration videos for an introductory circuitry course. Our preliminary results indicate that the students enjoyed watching the lectures and felt more confident in the laboratory section of the course after seeing relevant demonstration videos.

Methods: This study was focused on the students of a large first-year circuit course at the University of Illinois Urbana-Champaign. The course services approximately 450 students each semester, with the majority of them being first year students in electrical, computer, systems, or industrial engineering. In the class, students attend in-person lectures twice a week for 50 minutes. Additionally, the students also attend a three-hour lab section once a week to obtain hands-on experience with circuit construction and analysis.

Throughout the course of the Fall 2023 semester, students in one lecture section of the course were shown a series of eight demonstration videos that introduced a variety of circuitry concepts. The videos were played for the students during the middle of lecture and were designed to replace a traditional lecture based presentation of a concept with a more engaging and memorable demonstration. These demonstrations started with a brief overview of the concept, and then showed a circuit demo that highlighted the concept in question. The instructor would pause the video and ask students to predict the outcome of the demonstration based on their existing knowledge of the concept. Students would then respond to a real time poll using an iClicker [13]. After a poll question, the demonstration would continue. The videos concluded by summarizing the main ideas of the demonstration. The videos were between 4 and 6 minutes in length and were recorded in the student laboratory using materials that the students had access to in their lab kits whenever possible.

For example, during a lecture on time varying signals we played a short demonstration video showing the construction of a square wave oscillator. We started the video by verbally reviewing a concept that the students had already studied extensively in the lab, the RC circuit. We then introduce a new concept that the students will see during their laboratory exercises: a Schmitt trigger inverter. Using a short animation, we showed the relationship between the input and output relationships of the inverter, as well as the hysteresis present in the component.

We then introduce a circuit diagram that creates a square wave oscillator with an RC circuit and Schmitt trigger inverter. To better facilitate the students' understanding, we verbally explained the operation of the oscillator, while showing a short animation demonstrating the flow of current and change in voltage over time.

After demonstrating the operation of the oscillator, we assessed the students' understanding of the video with a short iClicker question. We paused the video, and asked what would happen if the resistance of the resistor in the RC circuit decreased in magnitude.

Rather than giving the students the answer directly, we switched the camera to an overhead view of the oscillator circuit, constructed of materials the students have access to in their lab kits. We overlaid oscilloscope data while we changed the resistance of the resistor. This showed the decrease in the frequency of the square wave, which answered the previously asked question.

To conclude the video, we highlighted the practical utility of this type of oscillator by connecting the output of the oscillator to a speaker and replacing the resistor with a photoresistor. We show how we can change the pitch of the sound that is heard by altering the illumination of the photoresistor. We conclude the video by briefly reviewing the operation of the Schmitt trigger and oscillator.

In addition to iClicker polls that were provided to the students during the video demonstrations, at the conclusion of several of the classes where videos were shown, students were asked to rate their enjoyment of the lecture, as well as their confidence regarding applying the material covered in their lab activities. These ratings were performed using a five-point Likert scale.

At the start of the semester, students were asked to use a Likert scale to rate their previous exposure to course material, preferred learning style, and confidence in their ability to perform well and focus in the course. At the end of the semester, students were asked to state the number of videos they observed, and use a Likert scale to rate their perception of their ability to focus in lecture, their confidence in lab, and if they felt that additional demonstration videos would improve their enjoyment and focus in lecture and their confidence in lab. In addition to asking students from the lecture section that had been shown all the videos, we showed an additional lecture section a single video and asked them the same end-of-semester questions.

Table 1: Video Topics and Data Collected

Video Topic	Lecture Shown	Type Of Data Collected
Voltage, Current and Resistance	2	Student Understanding
Introduction to Circuit Diagrams	Not Shown	N/A
Capacitors and MOSFET Intro	5	Student Understanding
Voltage Dividers	7	Student Understanding, Enjoyment, and Confidence
Square-Wave Oscillators	9	Student Understanding, Enjoyment, and Confidence
Thevenin Circuits	15	Student Understanding
Diodes	17	Student Understanding
BJT Amplifiers	20	Student Understanding, Enjoyment, and Confidence
MOSFET and Effective Resistance	24	Student Enjoyment and Confidence

Results: One of the major research questions we wanted to answer was the impact that prerecorded demonstration videos had on the students' enjoyment of their time in lecture. To assess this, at the end of four of the lectures where students were shown videos, we asked them to reflect on whether the demonstration video improved their enjoyment of the lecture. We found that in all four of the lectures, between 64% and 71% of the students indicated that they "Agreed" or "Strongly Agreed" that the video had improved their enjoyment of the lecture. Furthermore, only 4% to 8% of the students reported "Disagreed" or "Strongly Disagreed" that the video had improved their enjoyment of the lecture. We have plotted these results in Figure 1.

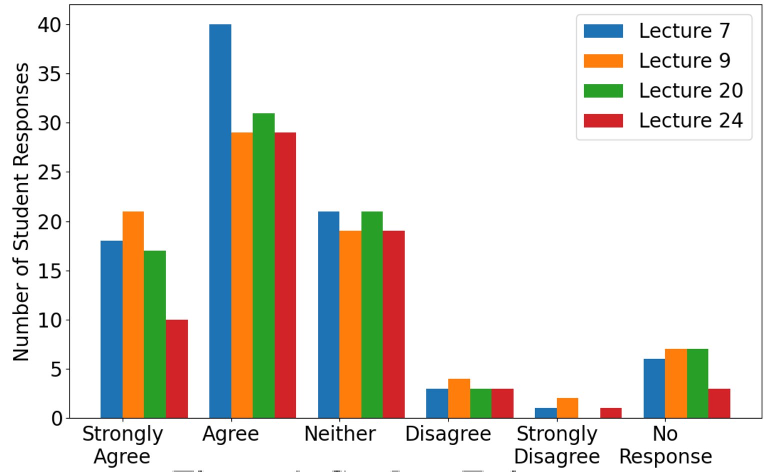

Figure 1: Student Enjoyment

We also wanted to determine if the demonstrations had a positive impact on student self-efficacy. In our own experience as instructors, we found that students lacked confidence in laboratory settings, and felt that the lecture and laboratory portions of the class were decoupled. When we asked students to rate their enjoyment of the lecture, we also asked them to rate their self-efficacy in performing tasks related to the demonstration in the lab. We found that these results were less conclusive with between 38% and 50% of students indicating that they "Agreed" or "Strongly Agreed" that they could complete the tasks, and between 10% and 33% of students indicating that they "Disagreed" or "Strongly Disagreed". These results are shown in Figure 2. However, we believe that this may have been correlated with the complexity of the demonstration and the difficulty of the tasks the students were being asked to perform, not the actual learning of the students.

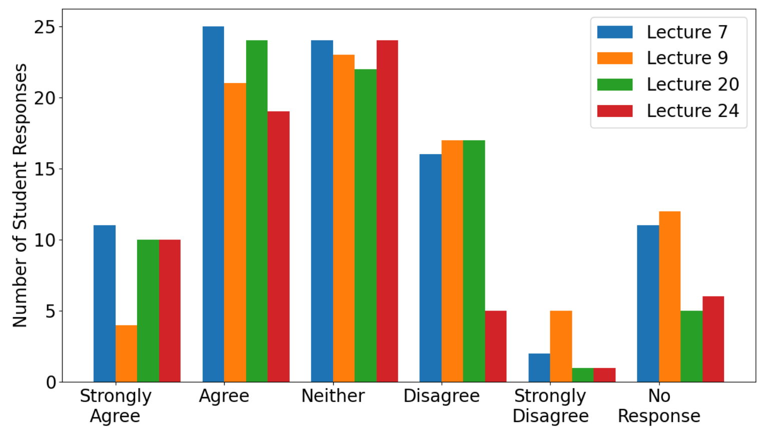

Figure 2: Student Self-Efficacy

To clarify the impact of the video demonstrations on the students, we surveyed students in two different lecture sections at the end of the semester and asked them if they believed that seeing additional demonstration videos would have better prepared them for the lab. We found that 59%

of students indicated that additional demonstrations would have better prepared them for lab, 25% indicated that additional demonstrations would not have an impact on their preparedness for lab, and 12% indicated that additional demonstrations would decrease their preparedness for lab.

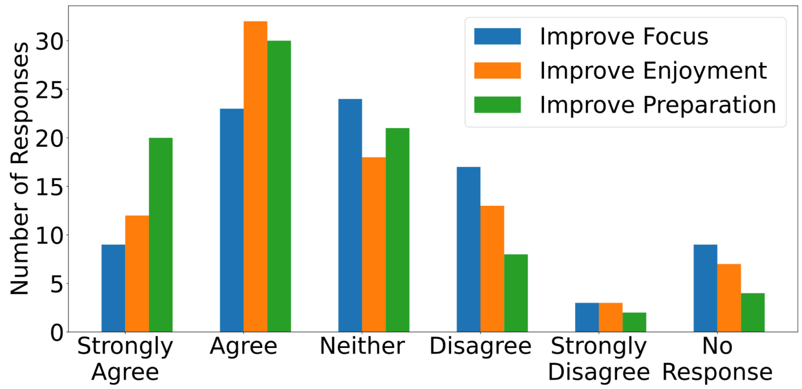

Figure 3: Impact of Additional Videos

We were also interested in the students' perception of how the sets of videos impacted their learning experience throughout the semester. To better analyze this, we asked students at the end of the semester to rate how they felt that additional demonstration videos would impact their focus and enjoyment in lectures. We also asked students to rate how additional videos would impact their preparedness for the laboratory section of the course. When we examined the students' perceptions of the impact of additional videos, we found that 45% felt that additional videos would have improved their focus in lectures, 28% felt neutral about the addition of extra videos, and 28% felt that additional videos would be detrimental to their focus. In terms of lecture enjoyment, 57% of students felt that additional videos would enhance enjoyment, 24% were neutral, and 18% felt that additional videos would be detrimental.

We also note that we collected data on students' understanding of the video material. However, we found that the percentage of students who correctly answered the questions that were given during the demonstration videos varied dramatically with the difficulty of the question and topic, so we did not perform further analysis of that data. In future work we hope to compare the results of questions asked during the demonstration videos to the results of asking the same questions to students who learned about the topic from a traditional lecture.

Discussion: From these results, we can conclude that within the context of our introduction to electronics course, lecture demonstration videos had a significant impact on the students' enjoyment of their time in lecture. While we are glad that students have enjoyed the videos, we want to ensure that allocating time to showing a video demonstration is more beneficial than utilizing that time for more traditional means of instruction.

To investigate this question, we explored how demonstration videos impacted student self-efficacy. We found that students were not confident in their ability to complete tasks related to the demonstrations that they were shown. However, we believe that this may be due to the complexity of some of the demonstrations. We did find that at the end of the semester, many students felt that adding additional demonstration videos would better prepare them for the laboratory section of the course.

From our data on student perceptions on the impact of the videos, we observed that overall students responded favorably to the videos we produced. However, it seems that the number of students who felt that the videos had a detrimental effect on their focus and enjoyment in lectures was substantial, indicating that the implementation of video demonstrations was not perfect, and leaves significant room for improvement. We also noted that students strongly felt that the videos did leave them better prepared for the laboratory section of the class, an additional benefit of the video project that positively impacted student learning outcomes.

As we have only run this project for one semester, we have several ways that we would like to improve. One major improvement would be the addition of better control cases. In the future, for each demonstration video we create, we would like to show it to one lecture section of the class. However, we will record student enjoyment and self-efficacy data from both a lecture section that saw the demonstration, and one that did not. This will enable us to better understand the impact of the video demonstrations, as we will be able to measure the impact of the video, while controlling for the difficulty of the content being presented. We also would like to encourage students to discuss their predictions of what will happen with their peers, rather than just answering with iClicker, as this has been shown to further improve student learning [8, 14]. Lastly, we plan to reshoot some of these videos utilizing best practices to improve their effectiveness, such as showing demonstrations from a first-person perspective [14], writing out key information as the demonstration is given rather than just displaying it [15], and focusing on visual tabletop demonstrations [16]. We believe that these changes can further improve the quality of demonstration videos to improve the overall educational experience of our students by providing high quality, exciting demonstrations to them in a course where they previously did not have access to demonstrations.

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Appendix: Survey questions

Survey 1 (Start of semester)

Q1: I am comfortable with circuit schematics (diagrams)
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q2: I am confident that I will do well in this class
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q3: I learn well by listening to lectures
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q4: I learn well by solving problems on my own
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q5: I learn well by watching someone solve examples
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q5: I can focus for an entire 50 minute lecture
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Survey 2 (End of semester)

Q1: Throughout the course of the semester the number of demonstration videos I saw in lecture was:
A: 5 or more B: 3-4 C: 2-3 D: 1 E:0

Q2: I feel I was able to stay focused through lecture this semester
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q3: I feel confident that I could understand the content in lab each week
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q4: I believe that additional demonstration videos would have improved my focus in lecture
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q5: I believe that additional demonstration videos would have improved my enjoyment in lecture
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree

Q6: I believe that additional demonstration videos would have better prepared me for lab
A: Strongly Agree B: Agree C: Neutral D: Disagree E:Strongly Disagree