Video Demonstrations Generated by Students in Statics

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Abstract

This paper summarizes the use of student-authored video reports in engineering mechanics: statics. The class is predominately the traditional face-to-face lecture having neither a laboratory nor demonstration component. An optional extra-credit project was offered to students allowing them the opportunity to conduct hands-on physical experiments using an introductory mechanics set with a set of established demonstrations. Instead of having students write laboratory reports, each student was required to submit a video report. The video contains the same information one finds in a written report: introduction, purpose, experimental setup, procedure, data collection, data analysis, and conclusions. The videos were made using a relatively inexpensive digital camera, edited, and made available using an internet accessible course management system. A teaching assistant assisted in shooting, editing and posting the videos. The entire class was able to view the videos made by other students. The benefits of the videos and student feedback from an end-of-semester questionnaire are reported. The biggest benefit is that students must do a good job of explaining their work and this promotes a more fundamental understanding of the material. Students viewed the videos from other students, which promoted student-to-student learning by seeing both good and bad examples of videos. This paper discusses the original assignment, examples of videos produced, implementation issues, student feedback, and suggestions for future implementations.

Introduction

Communication skills are important for engineers. Having read many student-authored laboratory reports, instructors often comment that students can mask a lack of understanding the material with confusing reports. In contrast, if a student is asked to explain their work if often reveals the depth of their understanding. In this work, students were required to verbally communicate results in order to help clarify issues and concepts, thereby strengthening understanding. The goal of this work was to explore the use of videos to develop a deeper understanding of course content by requiring students to explain their work verbally and have their explainations recorded and available for other students to view.

The idea for this work comes from events occurring in the culture. One sees that students are engaged with multimedia in their lives outside of the classroom. Starting in about 2005 there has been an explosion of videos shared using the internet. The site YouTube was activated in February 2005, and saw explosive growth through 2006 and was acquired by Google in October, 2006. The typical student has viewed many of these videos and is familiar with both concept and technology. Nearly everyone can generate a video and distribute it for viewing. With inexpensive video recorders/cameras they can make short clips that are then shared with others.

Videos are not just entertainment but can be highly engaging for the person who produces the video as well as the viewer. It is hard to predict how the internet media like video will continue to be used. Growth of entertainment is anticipated, yet the popularity of videos having historical or educational value is growing. There may be new educational uses, especially when integrated into a course management system with access restricted to those enrolled in a course.

The goal of this work is to explore uses of internet accessible videos, to promote learning and student success in a traditional engineering course like statics. A statics class has a reputation of being difficult for many students and the use of videos may be a mechanism by which students become more engaged with the material. When first conceived, a concern was that students would lack the equipment needed to generate videos. This may not be the case in the future with cameras being in phones. But for this work, the instructor provided a digital camera which was capable of recording video, as well as an undergraduate teaching assistant (TA) who assisted in shooting, editing, and publishing the videos.

In addition to promoting verbal communication and understanding, another goal was to investigate the reuse potential of the videos. It was thought that once produced the videos may be of instructional value to students who might view them. Although this was a possibility, it was rather remote compared to the focus being on the educational value to the student who produced the video. By producing the video, this promotes reflective thinking and synthesis of concepts. The idea is that the video will reflect poor understanding quicker than a written report. It may be harder for the student to "fudge" on a video where on a written report it is easier to fill the pages with content that may have the appearance of correctness but is largely irrelevant, inconsistent, or incorrect.

Video Assignment

In the class: EGR 2103 Statics, semester, students were given an optional extra credit assignment which had two parts. The first part was to make six video tutorials. The instructor decided to use the description "tutorial" instead of "report" because this exercise was promoted as a way to learn since "teaching is a great way to learn." Students were asked to explain their work, as if they were giving a tutorial to other students, so that other student could understand the work.

Each student who participated was required to produce six short (2 to 5 minute) videos. The students were directed to a web site to see some produced for engineering education[1]. Although it was not originally explained as a video laboratory report, the videos had all of the components of a laboratory report. Students were expected to start with an introduction, purpose, description of equipment, demonstration of usage, presentation of data, analysis of data, comparison to theory, and final conclusions. In order for it to be manageable, they were expected to keep it short and less than 5 minutes if possible.

The first five experiments were selected from Pasco's Introductory Mechanics System[2] as shown in Figure 1. The set has a total of 13 experiments in three areas:

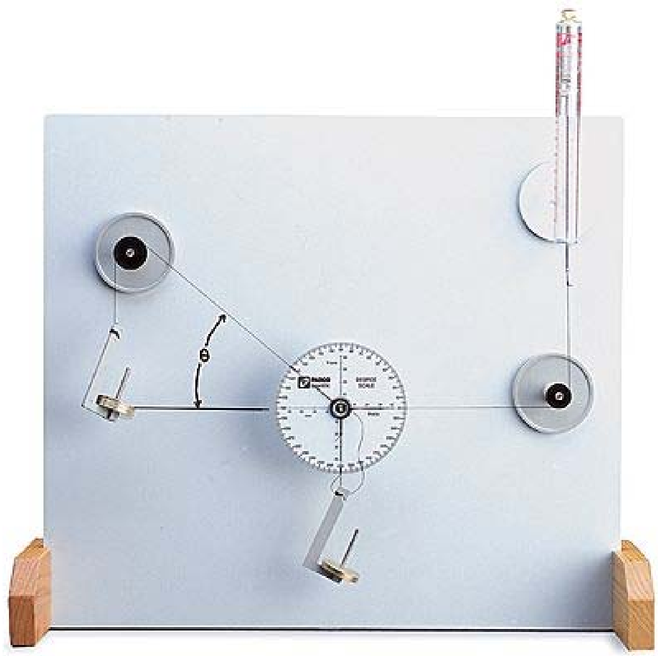

Figure 1: Pasco's Introductory Mechanics System[2]

Basic Experiments:

1) Measuring Forces: Hooke's Law
2) Adding Forces: Resultants and Equilibrants
3) Resolving Forces: Components
4) Torque: Non-parallel Forces
5) Torque: Parallel Forces
6) Center of Mass

Advanced Experiments:

7) Equilibrium of Physical Bodies
8) Forces on an Inclined Plane
9) Sliding Friction
10) ~~Simple Harmonic Motion: Mass on a Spring (Dynamics)~~ not applicable
11) ~~Simple Harmonic Motion: The Pendulum (Dynamics)~~ not applicable

Simple Machines:

12) The Lever
13) The Inclined Plane
14) The Pulley
15) Designing a Balance Beam

The 50 plus page manual for the equipment was available online from Pasco. The write-up provided with the equipment is well written and needs little clarification. Each student had to select one from each of the following sets: 1-3, 4-6, 7-9, 12-13, 14-15. For example, each student had to do either experiment 1, 2 or 3. Once a few students picked an experiment, subsequent students were encouraged to pick experiments that had not been done by others.

In addition, each student was required to design a demonstration. The demonstration was to explore one of the topics discussed in the class, such as moments, equilibrium, friction, center of mass, or stability. The student was not required to use the Pasco equipment for the last demonstration.

Figure 2 shows a student during a typical introduction. The standard introduction was to give the student's name and exercise name and a short summary about what was to be covered. The equipment often was placed in an empty bookshelf at a comfortable height so that the student could point out items as the experiment was explained.

Figure 2: Student before Pasco Equipment on Bookshelf

Each student was to create a video tutorial describing the experiment. Students were allowed to pair-up to assist one another with the projects; however, each had to produce their own video. When possible, each student used different angles/forces/data for the demonstration.

There was a sign-up list to use a room to make the videos. The room was a temporarily vacant office having a marker board, bookcase, desk, and computer. Also, each student was restricted to make no more than one video per week. This was to avoid a rush of video making in the final weeks. A senior-level undergraduate student was hired to assist with each project, especially the formatting and uploading of files to a common location for viewing by other students. They were put into the course WebCT page.

Feedback

Each student was required to watch each video that was uploaded into WebCT and provide feedback. The videos could be viewed from computers at UTSA (for speed) or from offcampus. Students were asked to answer specific questions, and this provided the primary source of feedback. Because the instructor was interested in compiling and evaluating the feedback, instructions explicitly required students: (1) use complete sentences, (2) be specific in responses and (3) limit the length of the responses. The responses for each of the six students (identified as S1, S2, S3, …) for the seven questions (identified as Q1, Q2, Q3, …) is reported here.

Q1. Describe what you learned by making the videos.

(S1) Making the videos gave me an excellent "hands on" explanation of concepts that are usually confined to graph paper. It just put some concepts in perspective for me.

(S2) By making these videos, the things that we were doing in class were reinforced. It was easier to grasp the concepts after seeing them in action. Personally I have always found it easier to grasp a concept if I am able to teach it to someone and this extra credit make you understand the concepts before you can ever make one video.

(S3) By making the videos I learned why the formulas we use for static problems work, the theory behind them and I have a deeper understanding in them.

(S4) By making the videos, you get a more hands on experience with the problems at hand. Sometimes in Statics, I personally would just get caught up in memorizing a formula or knowing where to plug in certain numbers. By performing the problems you are forced to understand what forces are acting on the object and what are they doing, especially with the Pascoe system. You have to make to Pascoe perform in the correct way to make sure your results are good.

(S5) While making these extra-credit videos, I realized that in order to be able to explain something you have to have a strong grasp and understanding about the subject. This is why I really had to try to understand the main ideas of the experiments. This consequently gave me the ability to explain better and more precise. I was able to give day to day examples about the experiments, which is important for people that have very little engineering background and end up watching these videos.

(S6) Teaching is an excellent way to ensure mastery of any subject matter. By studying and conducting the experiments I was able to more easily internalize the physics concepts.

Overall, the responses were positive. Students believed they needed to have a strong understanding of the material to explain the problem in the video. Most of the video time was used while the student explained things, as shown in Figures 3 and 4.

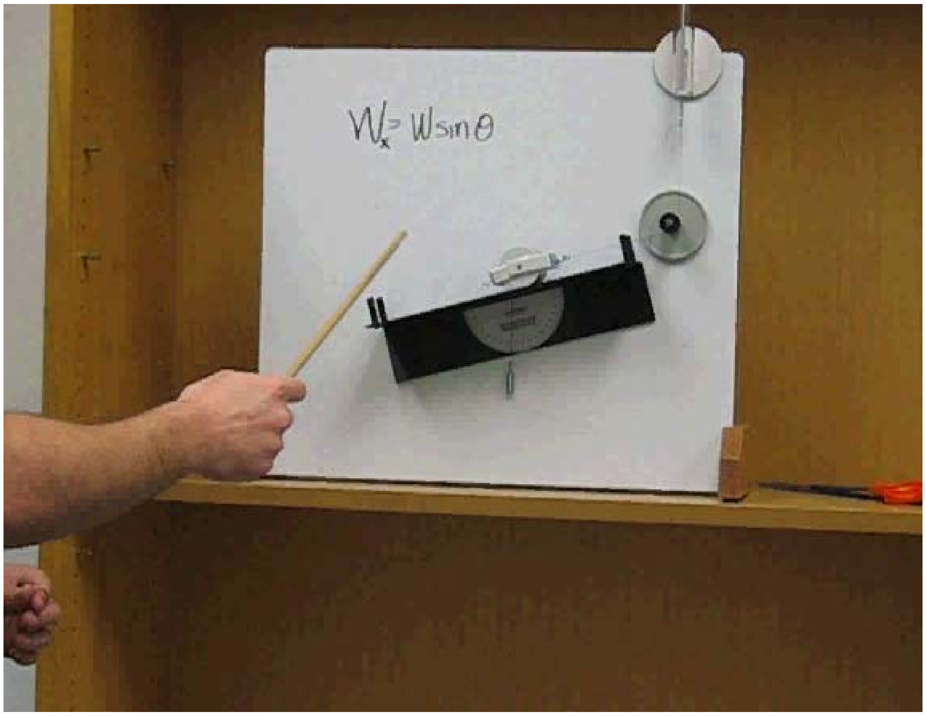

Figure 3: Student Explaining Setup and Theory during Video

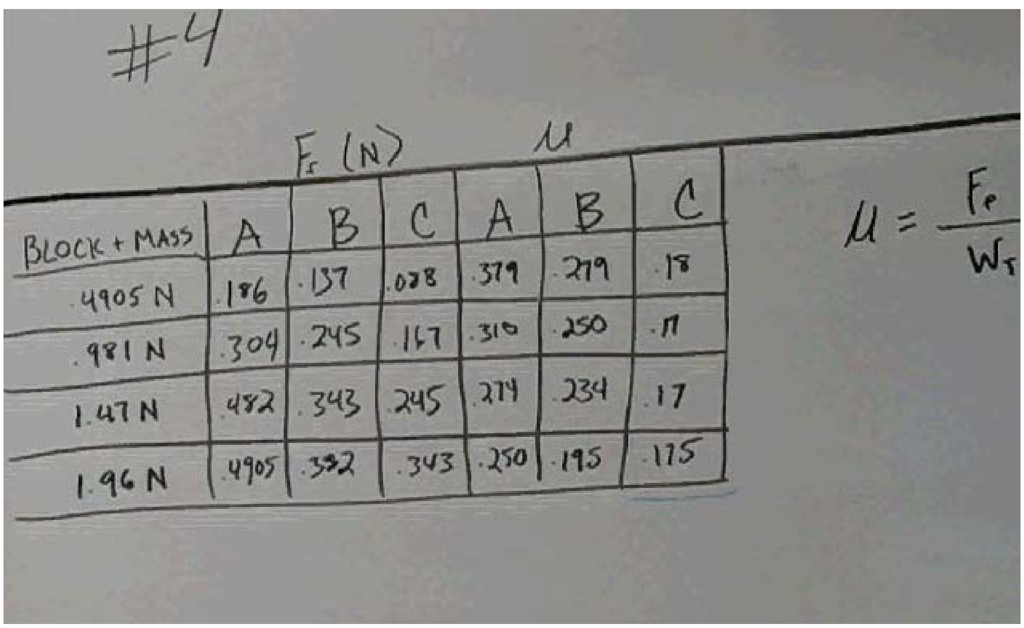

Figure 4: Example of Data and Analysis during Video

Q2. <u>Describe what you leaned by watching the videos from other students</u>.

(S1) Watching the other videos just reinforced the whole "hands on" concept. Having someone explain something in their own words is always helpful. Some things "clicked" when I heard another student explain them.

(S2) Watching other student's videos showed me that personal style completely changes the way in which a topic is brought across. The better at public speaking the student is the smoother the video is and the better the ideas and concepts are conveyed to the audience. This made me concentrate harder on my word choice, speed of speech, and volume during my experiments so that I came across as confident and knowledgeable.

(S3) To make sure I include everything from the experiment so that someone else watching knows what I am talking about. To speak with confidence so that other people watching the videos will have assurance that I know what I'm talking about.

(S4) I just picked up other things that I maybe didn't know or didn't say during my video. It is always good to hear something from a different point of view. This allows multiple ways to understand it and they are all good answers.

(S5) By watching other student's videos, I was able to see how I could make improvements in my own. I was able to see how they used graphs, charts and other types of visual aids in order to help them explain.

(S6) The other students have different presentation styles and added additional comments to each experiment.

Overall, students feedback was that (i) you can learn by watching another's video, (ii) presentation and word choice are important, (iii) confidence and attitude are important, (iv) the use of graphs, charts and other visual-aides help convey information.

Q3. <u>Was the use of the Pasco equipment positive or negative?</u>

(S1) Positive.

(S2) The Pasco equipment was highly effective and would rank it as extremely positive influence to the objectives of statics.

(S3) Positive at times and easy to work with, but negative at other times such as accuracy and limitations of the equipment.
(S4) Positive, but maybe at some times it needed a little help. It's definitely a good idea. This way the students don't have to bring their own stuff and this promotes more people to do the videos.

(S5) The use of the Pasco equipment was positive. It allowed me to be able to show a visual outcome of the experiment. By doing so, people were able to know what the numbers in their equations meant.

(S6) The "lab in a box" set-up worked very nicely because all of the components fit together and were the appropriate size for the room and the video camera.

Overall, students liked the well-designed “lab in a box” approach so that they were able to get meaningful hands-on results with reasonable effort.

Q4. <u>How effective was the final exercise, compared to the pre-defined Pasco labs</u>?

(S1) The final exercise was definitely more challenging. I found it much more difficult to think up an experiment I wanted. This isn't a bad thing however, and it definitely helped. I think having the combination of the two is great.

(S2) The final exercise was definitely fun and tested the creativity of the student and showcased their style. The final exercise showed that the extra credit doesn't have to be boring and you can run with an idea and make it your own.

(S3) It was a good exercise; one has to put a lot of thought into it before filming. It was like a real world statics problem to me. It took more time obviously because it wasn't put together for you.

(S4) I liked it. It was personal so you could do whatever material you liked throughout the semester. It defiantly wasn’t challenging. The book is full of problems and if you were desperate you could pull one of those.

(S5) The main idea for the final exercise was to find a day to day example in which we could be able to explain how our experiments were connected. I felt this experiment would be much easier for our audiences to grasp.

(S6) I especially enjoyed searching for a real-world application the material I learned. The concepts can be applied to a wide variety of situations.

Overall, students liked the non-prescriptive, final, hands-on assignment. For most students, it was more challenging and the students invested more time and produced a meaningful video. Some of the projects were informative since they explored stability such as shown in Figure 5 dealing with “slip or tip” of a water bottle.

Figure 5: Example of “Slip or Tip” Final Project

Q5. What weaknesses need to be addressed if students are to make additional videos next semester? How should the directions be changed?

(S1) I really don't see any problems with the whole procedure; more students should take advantage of it.

(S2) The weakness I noticed was the lack of participation in the extra credit. I think assigned groups might help more people participate while keeping it extra credit. Make it so that each person in the group has to be the speaker in at least one video. In addition you can have the group members grade each other. I liked the experiments and think those should not be changed.

(S3) To come prepared, know what you want to say before filming and spend time working it out before.

(S4) It would be nice to address some of the Pasco problems before students jump into the experiments. Let them know that the spring scale can’t be touching the sides or look for the friction side on the sliding block. The directions are fine. It’s not too difficult to understand those, especially if you are working with a partner.

(S5) When I became a spectator in the review of these videos I realized that we needed the use of more graphs, tables, etc. Another issue is the visual interaction between the lecturer and the audience. As an audience it was not enough just to hear the lecturer.

(S6) Students should probably spend more time preparing for the video presentation. The directions might let students know that notes cannot be used and maybe an estimate on preparation time.

Overall, one area for improvement mentioned by the TA was the need to encourage or require students to be better prepared. About half of the students had carefully read the instructions and were prepared, while the some adopted the just-in-time attitude. This was frustrating for the TA.

Q6. What strengths need to be retained if students are to make videos next semester?

(S1) John was VERY helpful to have in the room for some guidance. Definitely keep him around. The scheduling was also convenient and easy.

(S2) Having many slots of time available for the videos to be made was awesome. It fit into almost everyone's schedule and helped me balance work and school. In addition, the videotaping is key. I saw it help to build the confidence of the students as the semester continued.

(S3) To keep the sign-up sheet on that door so one can be prepared. The encouragement of completing the videos.

(S4) I like how it is a replacement grade. It is a good amount of work and you have to stick with it to get full credit. It should be for the students who really want to take advantage of the project.

(S5) The use of the Pasco equipment is important, because it allows us to find out how the physical aspects work.

(S6) The sign up sheets provided a wide range of times for me to choose and provided the flexibility I needed with my other classes. I like using the Pasco equipment because it was allowed me to focus on the procedure and information instead of the equipment.

Overall, the TA was well liked and did help students with set-up, data collection, explanation, and analysis. One surprise was that each video probably took about 2 hours to create, so ample room time was needed.

Q7. Has this exercise improved your grasp of Statics concepts? How?

(S1) Yes, most definitely. Simply "working out" the problems is excellent. It really helped reinforce simple concepts for me.

(S2) While I had the basics of Statics down throughout the course, actually doing the experiments allows for seeing things in action. As we discussed last semester, seeing something done is worth its weight in gold. I was able to work my way through difficult problems by visualizing it and the experiments helped me visualize the problems. Also being able to talk about the concepts gave me confidence in my work so I felt more confidence in tests and quizzes.

(S3) Yes it has definitely has, understand the theory behind all those formulas and how they are being applied in real life situations.

(S4) It has absolutely increased my skills in Statics. Any extra problems that a person does increases their concepts but, like I said before, this is more hands on. You have to find an answer and figuratively speaking fill in all the blanks. There is no back of the book to look for your answer.

(S5) It has improved my grasp on Static's. The explaining of experiments has made me more aware of the topics and what is their main purpose.

(S6) Understanding the concept of torque has been challenging, but after having hands-on experiences I was able to understand and apply the information to other situations.

Overall, students stated the exercises were helpful in developing a deeper understanding of the material.

Conclusions

Although ten students started the video projects, only six completed the work. The students were motivated by the extra credit they could earn, and the idea of learning was not a significant motivating factor for most students. Because many started but did not finish, one concludes that the videos were not as easy to produce as initially thought. Students found it difficult to stumble through the process and the teaching assistant encouraged students to come prepared. If they were not preparted, the teaching assistant complained that they were wasting time. This encouraged students to be prepared or drop the pursuit of the extra credit.

It was also found that the videos were more engaging for students to create. The feedback highlighted that students did learn by having to explain the approach, data, analysis and conclusions of their work. The video editing and final production was more time-consuming and difficult than originally anticipated. Overall it was a valuable exercise that was engaging for the students and in the future it will become easier for students to generate video reports. As the capabilities improve, video reports will not only have the benefit of forcing students to explain their work, it will also afford a better way to show how the experimental system was used. Videos appear to be well-suited for dynamic behavior where one can see movement.

The final project required students to design and conduct an original experiment. The educational value of the open-ended experimental design project was found to be very helpful. Students displayed more creativity and appeared to enjoy the final project more than the earlier scripted projects. Student feedback for the end-of-semester questionaire reinforced this observation that these projects helped develop a deeper understanding of the concepts of the material covered in the class.

References

1 Colorado State, http://www.engr.colostate.edu/~dga/video_demos/index.html.
2 Pasco, "ME-9299 Introductory Mechanics System," http://www.pasco.com/.

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