New Video Tool for Demonstrations in Distance Education Statics

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Abstract

Basic demonstrations can help students connect the concepts from class with their own understanding of how the world works. Previous research has focused on inexpensive demonstrations for Statics which have been well received by the students.[1] But such demonstrations best serve the students in the first couple rows of an in-person delivery of Statics. Conventional video can show a demonstration but does not easily serve for teaching modeling the system.[2] Lightboard technology which has been used at several universities for teaching physics and engineering is adapted here to show a Statics demonstration and teach the accompanying free-body diagram (FBD) and equilibrium modeling in the same short video.[3,4] One demonstration from Statics was filmed including the lightboard to assess student learning and get feedback from the students. Student experience is being tracked for several groups of students: those who saw the demonstration in person, those who saw a synchronous video of the classroom through distance education using a polycom link, and those who saw an asynchronous video through distance education.

Keywords

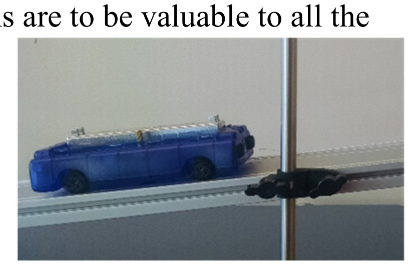
Statics, flipped classroom, demonstrations, lightboard, video

Section 1: Introduction

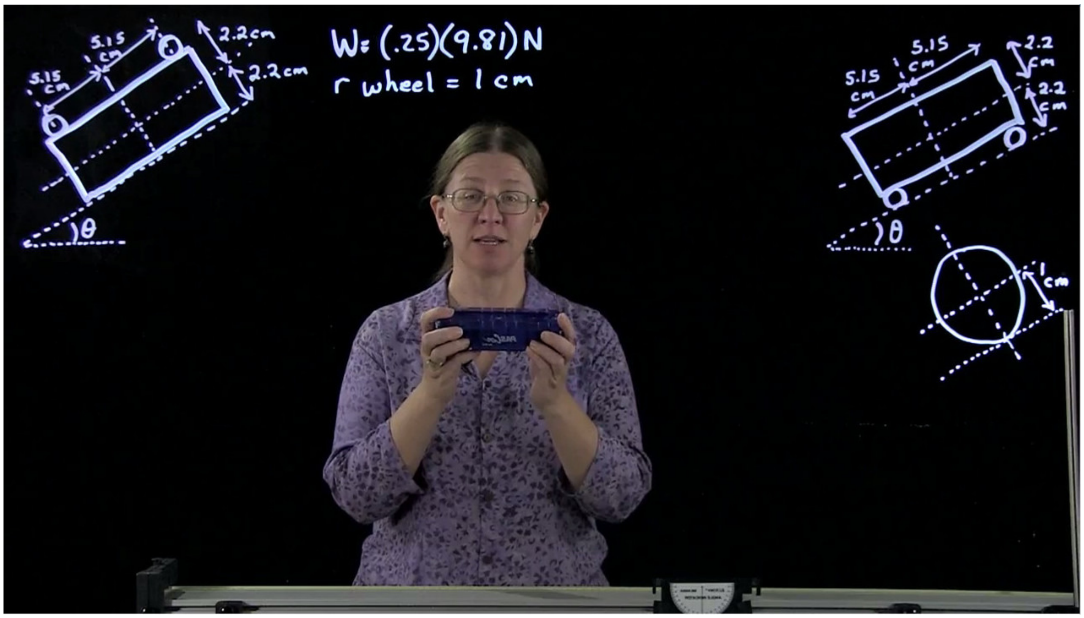
Statics at NCSU has been taught as a flipped class beginning in 2010.[5] While class time has principally been spent with students working textbook-style problems in class, demonstrations during class time have been gradually added over the last several years.[1,6]

Some of the demonstrations used in Statics are quite simple: for example two students holding an elastic cord to discuss the equal and opposite forces in a two-force member and how forces are defined for trusses by the method of joints. Some of the demonstrations become quite complicated: the force distribution system (as developed by faculty at Clemson University in conjunction with Pasco) takes time-varying force data from a ball rolling on a simply-supported beam.[7,8] Demonstrations were considered when they directly related to the material covered in class and consumed no more than 10 minutes of class time.

Demonstrations done in a classroom setting are not equally accessible to all the students: some students are absent, some sit in the back of a large classroom, and some are taking the class as a distance-learning class either synchronously or asynchronously. If demonstrations are to be valuable to all the students rather than just the students who sit in the front row, then the demonstrations need to be recorded or accessible in some other way. Such recordings also need to be compared to the students who saw the demonstration in person. One demonstration used in Statics compares rolling and sliding friction for a car on a track. This demonstration was selected to be recorded using the lightboard.



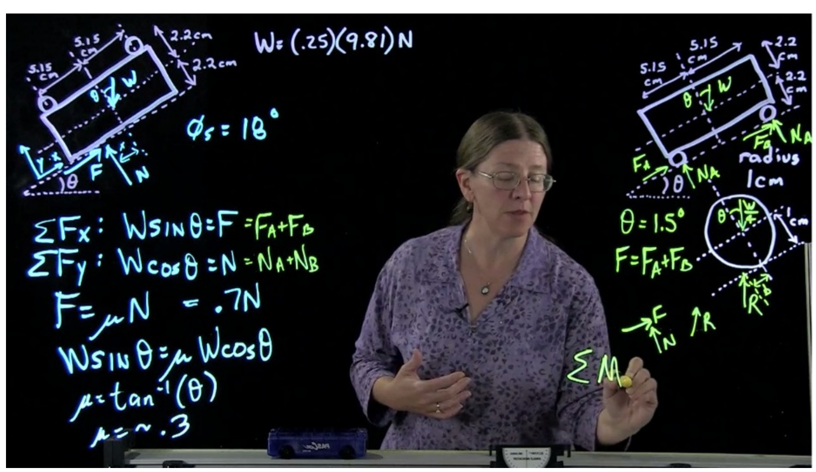
Conventional video presentations can certainly be used to teach free-body diagrams and equations of equilibrium. These conventional options force a presenter to choose between turning his back to the camera or merely pointing at previously drawn information. Either choice can be off-putting for students. Lightboard technology allows the presenter to face the students with demonstration props and to write on a sheet of glass to show free-body diagrams and solve equations.



Several different sections of statics were shown the demonstration in a variety of ways before they viewed the lightboard video. The demonstration was shown in person to a small group of students in Asheville; this group of students is designated the in-person group. The demonstration from Asheville was simulcast using polycom to a group of students in Raleigh and Havelock, a group I call the synchronous watchers. A Mediasite recording of the previous semester was shown in several sections that could not see the synchronous demonstration from Asheville; this group of students is referred to here as the asynchronous group. There was a fourth group of students considered who was not in class at all to see the demonstration. After class the video was made available to all the students in Statics embedded inside a survey about its effectiveness.[9]

Exam data for all four groups is compared here to a student group before any demonstration was available. Additionally student survey data and anecdotal student responses are presented to assess how useful the students found the video demonstrations.

Section 2: History of Lightboard



The lightboard uses side LED lighting on a large pane of glass to make a transparent white board. An instructor stands behind the light board and writes on the board with florescent markers. The resulting video is digitally flipped so that the viewer sees the writing appear left-to-right. (Despite the photo here, I am not left handed.)

Similar products have been developed by several researchers. Alex Anpilogov built a LED board in the UK for tutoring mathematics. Matt Anderson, a physics professor at San Diego State University, independently developed a similar technology which he called Learning Glass.[10,11,12] He and his colleagues showed an increase in feelings of immediacy or connectedness to the professor with the Learning Glass technology though they found no statistically significant difference in learning outcomes with and without the Learning Glass videos.[13]

John Mocko published an open source hardware guide for building lightboards.[14] Stembrite, a local company, has built several lightboards using Michael Peshkin's specifications including a portable lightboard which can be moved from one lab to another.[4, 15]

Setup and filming for the single lightboard video produced for this study took place at Stembrite's headquarters and took about 90 minutes. Post-processing was handled by Stembrite in a few hours. The lightboard technology allows for showing slides or overlays on the board though that functionality was not used in this study.

Section 3: Results

Two major questions were of interest here. First, was the demonstration (with or without the video) helpful for student understanding? And second, how did the lightboard video demonstration compare to the other options for showing students the demonstration?

Students in Fall 2015 were asked to calculate the rolling friction: "The six-wheeled dump truck weighs 15 tons at the moment. The wheels (with radius 18 inches) have a rolling resistance of 0.5 in. on the asphalt. Find the force needed to keep the truck moving forward." The question was a multiple-choice question. This question formed the baseline for whether students were able to calculate rolling friction correctly.

Student responses are shown in Table 1. Unfortunately the question as written in 2015 had the correct answer equal to none of the above which made this a less-than-perfect exam question for identifying whether students understood the question. (Anecdotally I have observed that some students will not choose none-of-the-above under any circumstances.) Some students may have gotten some other completely incorrect answer and chosen none of the above. Additionally the correct numerical answer with incorrect units was present on the question as asked.

Table 1: Exam Results Fall 2015

Answer choice	**Feedback**	**N**	
none of the above	Correct. The answer should be 100. lb not 100. kip.	133	35.6%
100. kip	Check your units. This should be 100. lb.	36	9.63%
2.40 kip	You have an extra factor of six in here somewhere. And you may not have accounted for the radius of the wheel.	66	17.7%
74.1 kip	You have an extra factor of six in here somewhere.	32	8.6%
3.60 * 103 kip	This is much too high.	8	2.1%
444 kip	This is too high.	7	1.9%
16.7 kip	Incorrect.	81	21.7%
50.0 kip		5	1.3%
[No response]		6	1.6%
	Total:	374	100%

All together, 45% of the students answered with either the correct numerical answer with incorrect units or answered none-of-the above in fall 2015.

The flipped class works best when students come to class prepared. Students are expected to watch short introductory videos before class, in this case two videos: a 4-minute video on belt friction and a 6-minute video on rolling friction. Viewing data YouTube showed 574 minutes watched from people in the United States leading up to that class period; this would account for only about 100 of the 370 people who were expected to watch the video. This topic falls during the semester immediately before fall break when students are famously non-compliant about completing assignments like watching a video. This video was also the second they were expected to watch. Estimates of views of the first video on belt friction were closer to 150 students.

The lightboard video was released during Fall 2016 inside a student survey. Students response rate was high since the survey was worth two points on their test 3 score: 78.6%. There were only three questions on the survey:

1. Before you watch the video below, estimate your own understanding of the topic of rolling friction.
   --- video shown ---
2. The purpose of these demonstrations is to help you connect your real-world common sense to the engineering analysis. Did this demonstration (regardless of how you observed the demo, in the classroom or on a video) help you make this connection to the math?
3. Is this video presentation more helpful or less helpful than what you saw in the classroom?

Given the low number of students who were prepared for class, it was not very surprising to find students struggling with understanding rolling friction: only 40% of the class indicated that their understanding was somewhat good or confident before watching the lightboard video.

Table 2: Rolling Friction Understanding

Estimate your own understanding of the topic of rolling friction.		
a. My understanding of rolling friction is very poor. I don't get it.	6	2.1%
b. My understanding of rolling friction is somewhat poor.	52	17.9%
c. My understanding of rolling friction is mediocre, neither good nor poor.	116	39.9%
d. My understanding of rolling friction is somewhat good. I sort of get it.	99	34.0%
e. I am confident in my understanding of rolling friction.	18	6.2%
Total:	291	100%

The demonstration was designed to help students connect a familiar, real-world situation with the free-body diagrams and equations of equilibrium needed to solve problems. The second question on the quiz asked students whether the demonstration was fulfilling that need.

Table 3: Connecting Demonstrations to the Analysis

Did this demonstration (regardless of how you observed the demo, in the classroom or on a video) help you make this connection to the math?		
a. no help at all in making a connection	0	0.0%
b. very little help in making a connection	3	1.0%
c. a little help in making a connection	112	38.5%
d. very much help in making a connection	175	60.1%
No response	1	0.3%
Total:	291	100%

Almost all students believed the demonstration was helpful with a remarkable 60% of those surveyed saying that it was very much help.
There was no marked difference between how the students felt about demonstrations versus how they felt about their understanding of rolling friction. Note that this survey happened after class time where the demonstrations occurred. Though the percentages vary a bit, the number of students who ranked their understanding as very poor who nonetheless took this survey was very small (N=5).

Table 4: Connecting Demonstrations Compared to Understanding

Understanding:	much less helpful	somewhat less helpful	neither more nor less	somewhat more helpful	much more helpful
very poor	0 0%	0 0%	0 0%	1 20%	4 80%
somewhat poor	0 0%	1 2%	1 2%	24 56%	17 40%
neither good nor poor	0 0%	0 0%	7 7%	49 51%	40 42%
somewhat good	1 1%	2 2%	4 5%	46 52%	35 40%
confident	0 0%	0 0%	2 13%	8 50%	6 38%

Students were very complimentary about the value of the video overall. Students' emails offered more feedback, uniformly positive. Student comments included things such as: " I think having these videos *in addition* to the more basic conceptual videos helps bridge the gap between the diagrams and actual demonstrations. It is sometimes difficult to see demonstrations in class because the room is so large, so this format allowed me to see the cart and track with the FBD's right next to it."

The last question on the survey asked students to compare what they saw in the classroom to what they saw in the lightboard video.

Table 5: Comparing the Lightboard Video to the Classroom

Is this video presentation more helpful or less helpful than what you saw in the classroom?		
a. I was not in the classroom to see this demonstration.	22	7.56%
b. much less helpful	1	0.34%
c. somewhat less helpful	3	1.03%
d. neither more nor less helpful than what I saw in the classroom	14	4.81%
e. somewhat more helpful	146	50.17%
f. much more helpful	104	35.74%
No response	1	0.34%
Total:	291	100%

When comparing the survey results to attendance records from class, there were an additional 20 students who rated the video as somewhat or much more helpful than what they saw in class even when the attendance records show that they weren't in class. These students and the student who did not respond to this question have been removed from the Table 6 results. The remaining students who were in class and who took the survey totaled 248 responses. These responses were segregated by how the students had viewed the video in the classroom.

Table 6: Comparing the Lightboard Video to the Classroom

Section:	much less helpful	somewhat less helpful	neither more nor less helpful	somewhat more helpful	much more helpful
Section 1 or 3 asynchronous video shown during class	1 1%	3 2%	9 5%	83 47%	80 45%
Section 2 or 605 day synchronous distance education	0 0%	0 0%	3 5%	39 65%	18 30%
Section 602 in-person demo	0 0%	0 0%	2 17%	6 50%	4 33%

The format the students had for class time did not noticeably change their opinion of the lightboard video.

The last comparison available was with the exam data from Fall 2016. I kept the none-of-the-above correct answer to control as best as possible with Fall 2015 data. The question was now a 30-kip train with six wheels instead of a 80-kip truck, but the format of the answers was kept identical.

Table 7: Exam Results Fall 2016

Answer choice	**Feedback**	**N**	
none of the above	Correct. The answer should be 833 lb not 833 kip.	125	33.9%
833 kip	Almost correct. Check your units. This should be 833 lb.	60	16.3%
2.50 kip	You have an extra factor of six in here somewhere. And you may not have accounted for the radius of the wheel.	31	8.4%
5.00 kip	You have an extra factor of six in here somewhere.	64	17.3%
8.33 * 10^3 kip	This is much too high.	3	0.8%
500 kip	This is too high.	7	1.9%
3.33 kip	Incorrect.	56	15.2%
50.0 kip	Incorrect.	19	5.2%
[No response]		4	1.1%
	Total:	369	100%

The number of students who correctly chose none-of-the-above was 35.6% in Fall 2015 and 33.9% in Fall 2016, essentially unchanged. There was a noticable increase in the number of people who answered with the correct numerical answer (even though the units were wrong): 9.6% of the students in 2015 had the correct numerical answer whereas 16.3% of the students in fall 2016 did. This increase represents scant data which would indicate that the presence of this additional video improved the understanding of the video. Further research should include better exam questions before and after videos are added to tease out whether student learning is improved.

During Fall 2015, 280 students were present in class to see the demonstration in person. During Fall 2016, that number was only 30. It is possible that being in the classroom with the demonstration could create an understanding that the lightboard cannot match, but there is not enough information here to show that any of the variance in exam data shown here is significant one way or the other.

Section 4: Conclusions

The production of the video was not terribly time consuming for a faculty member though it did require minimal post-processing by Stembrite. The use of an outside company made it financially unfeasible to correct small mistakes in the video since reshooting it would mean setting the entire video up again.

Student reaction was very positive. Students believe the demonstrations help them connect to the mathematics which is very encouraging. There are at least ten other demonstrations which are regularly used in Statics. Future research should involve producing all of these for the students who cannot be in the front row to see the demonstrations.

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Anna Howard received her Ph.D. in Aerospace Engineering from Penn State University studying the aeromechanical stability of tiltrotors. She is currently a Teaching Associate Professor in the Mechanical and Aerospace Engineering Department at NCSU where she serves as the course coordinator and primary instructor for Engineering Statics and has led the large course redesign project for MAE 206. Her redesign aimed to combine online materials with in-class working groups in a flipped format with the goals of providing more "just-in-time" learning opportunities and reducing drop/withdraw/fail rates as much as possible. Through Engineering Online Dr. Howard also teaches Statics at Havelock Community College, the University of North Carolina at Wilmington, and the mechatronics program at the University of North Carolina at Asheville.