Short video clips to increase student engagement in mechatronics

Pranav A. Bhounsule, Randall D. Manteufel
Department of Mechanical Engineering
University of Texas at San Antonio
pranav.bhounsule@utsa.edu and rmanteufel@utsa.edu

Abstract

Publicly available video clips have been used during traditional lectures in a senior-level mechanical engineering mechatronics course. Short video clips come from a variety of internet sources. The instructor selects the videos to reinforce mechanical and electronic concepts covered in the course. It is proposed that two to four short videos that last from 30 to 120 seconds, regularly shown after 20 minutes into a lecture, are most effective in engaging students. End of semester student surveys have been conducted to gauge the effectiveness of the videos. Results show that students "strongly agreed" that videos (1) motivated them to attend class, (2) improved their understanding, and (3) helped them remember concepts, and (4) motivated them to explore the subject matter beyond the classroom. It is proposed that video clips can effectively supplement classroom lectures leading to increased student learning.

Introduction

Engineering classes are between 50 minutes to 3 hours long. Thus, one of the challenges for the instructor is to be able to sustain the student interest and level of engagement for that much period of time. Indeed, Wankat [34] quotes a number of studies that that suggest that student attention span lasts for only about 15 minutes. See Figure 1 for an illustration of the effect [1].

If student attention span does fall during the course of the lecture, then it presents a challenge for the instructor to sustain their attention span for longer periods. The most successful and widely reported approach to engage students during the class hours has been what has been the practice of active learning [26] [29]. In active learning, students perform learning activities in the classroom either alone or in groups [8].

Middendorf and Kailish [20] give an interesting suggestions for active learning. They suggest to break the lecture up into chunks of 20 minutes of lecturing followed by few minutes of active learning exercises such as problem solving or classroom discussions. This method overcomes the attention span problem, that is, it strives to engage the students once again after their attention span diminishes. However, one caution here is that sticking to the same schedule every class will reduce the impact of the change-up, so it important to vary the time intervals. One can use iClickers for soliciting answers from student during the periods of active learning [25]. The instructor asks questions in the class and students use a hardware device called an iClicker to respond. Another alternative is to use the website Poll Everywhere [24], wherein students can use a browser or their phones to answer questions posed by the instructor.

In this paper, we explore the use of short videos, majority of which came from YouTube, for class

engagement. YouTube is an online video sharing website that provides extensive commercial and non-commercial videos free of charge. The use of YouTube for teaching is not a new idea. Liberatore developed YouTube Fridays [18] to teach the Thermodynamics course. The students found relevant videos pertaining to the course and shared them with the instructor. These videos were then screened at the beginning of the lecture on Fridays and were followed by a class discussion. Trier [33] used YouTube videos for Cultural Studies and Education class, where again, student searched and contributed relevant videos followed by class discussion. Burke et al. [9] used YouTube videos for health education course but only 1-5 videos were shown for the entire semester. YouTube videos have been used for nursing education [10], anatomy education [15], sociology education [30], and dentistry education [17].

Our main diversion from the previous studies is to use YouTube videos a few times during the lecture to maintain student attention span. In particular, we show YouTube videos every 20 minutes of lecture time. Over the course of 15 weeks, we showed about 85 YouTube videos to the students. The YouTube videos that we chose served to supplement the lectures by emphasizing the practical application of the concepts taught in the class. At the end of the semester we did a survey to assess the effectiveness of the YouTube videos on student attention, engagement, motivation, interest, attitude, remembering, and understanding the subject.

Mechatronics course and teaching challenge

Mechatronics is a 3 credit, 4000 level core course offered in the Mechanical Engineering Department at the University of Texas at San Antonio (UTSA). In this course, the students are taught about resistors, capacitors, inductors, diodes, transistors, data acquisition including analog to digital conversion and digital to analog conversion, micro-processor programming, sensors, and actuators. The course includes two 75 minutes lectures and 3 hours of laboratory per week.

The Mechatronics course is offered to Juniors/Seniors in the Mechanical Engineering Department. This is the second (and last) electrical-related course that the Mechanical Engineering students take at UTSA; the first course being a Circuits course offered by the Electrical Engineering Department and taken in the sophomore year. One of the prime challenges is to make this predominantly electrical course, accessible and interesting to the Mechanical Engineering student, many of whom are not inclined towards learning electrical engineering concepts.

"In-Class" YouTube videos to supplement classroom lectures

Students often express the sentiment that they are motivated when they can connect the taught concepts with practical applications. We hypothesize that showing videos that illustrate practical applications to supplement classroom lectures, might spur student interest and lead increased engagement.

YouTube [38] is a video sharing website, that provides free and diverse set of videos that are uploaded by users round the world. We believe that YouTube videos provide a great resource that can potentially enhance classroom teaching. Moreover, the Google owned YouTube website offers a powerful search bar that uses a keyword based search. Besides, YouTube recommends videos to

watch based on past searches. These features make it quite easy to find videos on YouTube.

Video Timing: The class is taught with 75 minute lectures and about two videos were shown per lecture. The typical format is to have one video after 20-25 minutes of class and a second after 45 - 50 minutes of class. Each video session is between 15 seconds at the minimum and 5 minutes, but the average time is about 2 minutes. In some cases, multiple videos are shown back-to-back. It is recommended that videos not be shown at the beginning of the lecture but rather 20 minutes into the lecture. Our choice of 20 minutes is based on the recommendation of Middendorf and Kalish [20].

Video Timing Variability: Though on average the videos were evenly spaced in 20 minutes intervals, it is important to note that keeping the video timing predictable is ineffective [20]. So, we never struck to the same schedule. For example, for one lecture we showed video once every 5 minutes, for a couple of lectures we showed videos towards the end of the class, for a few lectures we started the lecture with a video, and so on. Keeping the video timing variable creates a sense of anticipation and help students stay alert.

One thing to note is that videos are not used to explain concepts. For example, a video that explains how a DC motors work would not be shown. Instead, the concepts are explained by the instructor and the videos are used to supplement the taught concepts.

Types of Video: The videos shown are aimed at making the students aware of various applications of concepts taught in the classroom. We give some example of videos used.

- **Videos on Electricity:** In the beginning of the semester when we were covering the basics, we showed videos about electrical safety. The videos included; (i) the electricity man [7], (ii) person getting electric shock from an eel [32], (iii) electric shock prank [11]. The latter was use to infuse humor into the classroom.
- **Videos on Arduino applications:** Arduino [2] is a hobby grade micro-processor that was used by the students on their project. There are a numerous hobby project using the Arduino. Whenever we found it hard to get a video relevant to the concepts taught in the class, we showed gizmos people built using the Arduino. Such examples included: (i) Arduino based turn-signaling jacket [3], (ii) Arduino based water gun for detecting and spraying cats [4].
- **Videos with one theme:** Often, in our YouTube search we found lots of videos related to a theme and we showed videos related to the theme. For example, one lecture the theme was alarm clocks [13] [35].
- **Videos for the sensor and actuators class:** For the lectures involving sensors and actuators, we found a plethora of videos. So we talked about a sensor followed by an application. For example, distance sensor and its use in car backing up system [36] . Also see Figure 3 on how videos were used to explain induction loop sensor that is commonly used to open gates.
- **Videos that illustrate novel solution to a known problem:** We posed the question to the class: **"**How does one motivate a person to take the stairs instead of the elevator?" After soliciting answers from the students we showed an idea where the steps in a subway station was replaced with musical stairs so that the stairs made sound when the person stepped on them thereby making it fun to take the stairs [27].

- **Videos that exploit a special event during the semester:** Since the class was offered in Spring, the Valentine's day occurred in one of the weeks. We used this opportunity to show Arduino projects for Valentine's day gifts [5]. One can show Halloween project ideas if the class is offered in the Fall semester.
- **Videos from movies/TV:** We occasionally showed funny videos from popular TV shows. For example, the Big Bang Theory (Halloween prank [31], Theremin [28]) Mr Bean Show (Infra red sensor [22], Induction loop sensor [21]), Jimmy Kiemmel Show (Lie Detector [16]), Oceans Twelve Capoeira scene to explain emitter-detector proximity sensor [23].

Finally, we list some of the advantages of using videos in this fashion:

1. **Meet ABET outcomes (h) and (j):** Outcome (h): the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; Outcome (j): a knowledge of contemporary issues. These outcomes can be naturally met by showing videos and then following up with a quiz or short essay where students demonstrate they have an improved understanding of the broad and varied impacts of engineering as well as contemporary issues facing engineers.
2. **Effective searching:** The search bar on YouTube offers effective means for quickly searching relevant videos. Although the instructor selected all of the videos shown in class, the time required to search for and select videos did not require a substantial amount of time or effort.
3. **Cost and Time effective:** The alternate to videos is to build a hardware demo illustrating the key concepts. This option is less attractive than videos because actual demos frequently cost more and take more instructor time. Another option is to have animations but these also tend to take more time to build compared to readily available videos.
4. **Crowdsourced videos:** YouTube videos provide a wealth of knowledge that many users have put the time and effort to develop. Using these videos for education provides an effective means of leveraging this knowledge.
5. **Demonstrating risks:** Some of the videos demonstrate risks and/or things that do not work. When students watch these videos they can be alert and avoid costly mistakes saving time and money. For example, properly discharging static electricity before touching inflammable substances. We showed a video [12] of a woman starting a fire at a petrol pump because of static electricity build due to the woolen sweater she was wearing.
6. **High course/instructor rating:** The first author taught the course for the first time in the Spring 2015 semester. The students perceived that the instructor put the effort and time to make learning fun and enjoyable. At the end of the semester, the standard end-of-course student survey results showed that the course rating was 4.59/5.0 and the instructor rating was 4.73/5.0. This rating is one point higher than the mechanical engineering department average.

Results and Discussion

Survey: To assess the effectiveness of the "in-class videos" we did a class survey using University course management software Blackboard [6] at the end of the semester, but before the final exams. The survey consisted of 8 multiple choice questions requesting student rank (on a 5-point Likeart scale), and a 6th optional feedback question. Here the students had the option of giving more detailed feedback about the videos. As an incentive to take the survey, one bonus point was added to the final

score if they completed the survey.

Instructions to the students before taking the survey: I am doing a pedagogical study to understand how in-class video presentations affect student perception of learning outcomes and engagement in the class. The survey is optional. However, I will give some extra credit for people who complete the survey. If you want the extra credit but do not want to take the survey just click option 6, "Do not want to answer", in the multiple choice questions and leave the feedback section blank. Also, if you feel that you do not want to answer some questions, feel free to enter option 6, "Do not want to answer".

The 8 questions and student response is shown in Table 1. The questions are grouped into three categories to in the analysis of the results.

Question 1, 2, and 3: Questions pertain to classroom engagement and motivation to attend classes.

Q1. The in-class videos motivated you to attend the class. Mean 4.17.
Analysis: Though the students "Agreed" that videos motivated them to attend the class, it was typical for only about 60% attendance every lecture. Perhaps, a better way to understand the correlation with student attendance is to try the video experiment with a control group. It is possible that attendance would be less than 60% without videos.

Q2. The in-class videos increased your attention span in the class. Mean 4.62.
Analysis: This supported the observation that students were more ready to ask questions about the class promptly after viewing a video. The normal practice is to follow each video with a brief

Q3. The in-class videos created a relaxing atmosphere in the class. Mean 4.77.
Analysis: The students seem to "Strongly Agree" on these two questions. The positive response is probably because video have a visual appeal and this help breaks the monotony of the lecture.

Question 4, 5, 6, and 7: These questions pertain to subject level engagement

Q4. The in-class videos improved your attitude towards learning the subject. Mean 4.40
Q5. The in-class videos increased your interest in the subject. Mean 4.48
Analysis: The students response was between "Strongly Agree" and "Agree". We believe that this is because the videos demonstrated practical applications and this helps them to see how concepts in the course are used in day-to-day life.

Q6. The in-class videos increased your understanding of the subject. Mean 3.92
Q7. The in-class videos helped you to remember the content. Mean 3.88
Analysis: The students response was "Agree". Since the videos did not get in to depth of the topic but instead supplemented the taught concepts, it is not surprising that the students did not have a strong belief that the videos help to understand the subject or help to remember the content.

Question 8: These questions pertain to learning beyond the class and the course.
Q8. In-class videos motivated you to apply the taught concepts outside the classroom. Mean 4.17
Analysis: The students response was "Agree". This is an indication that the videos help the student to apply the concepts beyond the classroom.

In addition, students were asked to give a detailed feedback about the videos. We have grouped responses into 6 observations based on the responses.

Observation 1: The authors believe that the prime reason why students liked the videos was that they showed them real-life applications of the concepts covered in the class. Here are some comments to this end.

> *"Great way to reinforce the topics. The reason for this is because they show the real life applications and understanding what they are doing makes it more beneficial."*

> *"They also helped me connecting the theory and practical part of the class."*

> *"They also showed up fun ways in which what we were learning could be applied to real-life situations."*

Observation 2: The reasons why students like the videos are; (i) make learning fun, (ii) for the entertainment value, (iii) break the monotony of lectures, (iv) inspire creativity, (v) incentive to come to class, (vi) help visualization, (vii) make student attentive, (viii) improves understanding. Here are some comments to this end.

> *"I think they're a great way to break the monotony of class. They definitely energizes me and helps me refocus my attention."*

> *"Fun should be part of the learning process: videos make that happen."*

> *"Also by creating a fun and relax atmosphere giving us a 5 minute break from lecture, which I find very helpful."*

> *"It inspired creativity along with a better educational experience."*

> *"The in class videos give the students an incentive almost to come to class. Some videos actually inspire the students to go out and apply what they are learning in there hobbies."*

> *"The in class videos help students visualize the topics better."*

> *"The videos are a great way to keep the students engaged and are good mini breaks during lecture."*

"The in-class videos absolutely help keep my attention during the class."

"They keep me engaged and provide a little entertainment when the learning process gets boring. They have also increased my interest in robotics and helped me in using my imagination along with my engineering background"

Observation 3: Videos help to improve the teacher-student relation. Here are some comments to this end.

"It shows me that the instructor put forth time to find these videos to help the students understand the concept of what is being taught. I appreciate that very much."

"The videos provided in class gave the lectures a fresh and fun feel, which allows the students to feel more amicable towards both the material and professor."

"They were among the best part of the class, and I looked forward to watching them. It was very interesting to be taught in this manner and i strongly encourage the professor to continue with this method of teaching."

Observation 4: Some student commented that the videos were not in depth or were sometime irrelevant but still recommended the videos for other reasons as mentioned above. Here are some comments to this end.

"Sometimes the videos didn't show or explain the complete application of the material."

"They are not kind of in depth. I mean I was trying to relate them to what we learn so far in the class from but it was kind of hard for me to see it from inside."

"They could be just a bit more relevant to the subject (I know, difficult to do since it would be hard to find videos that deal specifically with subject material). Ideally, of course, that would improve the learning experience which was already great."

Observation 5: However, in dealing with observation 4 that the videos were not in depth, some students were encouraged to seek more information by themselves. Here are some comments to this end.

"I think that the videos should pertain to the subject matter and the components which are being taught that day in class. For example, some animations or simulations of what the components actually do to provide a visual interpretation of the subject matter. I found myself looking on YouTube to figure out what the components do so I could get better understanding."

"Though sometimes the discussion was a little over my head it encouraged to look into the subject matter more and fill in the blanks."

Observation 6: Some students recommended videos for other engineering classes. Here are some comments to this end.

"I would hope to see them more in engineering classes where concepts can get dull and attention spans can get distracted."

"It provides examples of real world applications which is an element missing from most classes."

"I think showing in-class videos that are related to the material taught is a really great idea. Many times are we taught things that we don't see any applications or actual videos of the studies that we are taking."

Conclusions and Future Recommendations

In conclusion, the "in-class" YouTube videos offer an effective way of engaging students in the class without overly eating into the lecture time. Our major findings are:

1. The video strongly increase the student attitude and interest in the subject matter. We speculate this is because the videos illustrate the practical aspect of concepts taught in class.
2. The videos strongly lead to increased attention span in the class. We speculate this was because of the videos were streamed at strategic times, after every 20 minutes of lecturing,
3. The videos strongly lead to relaxing atmosphere in the class. This was because the videos lead to classroom discussion.
4. The videos had a somewhat positive influence in motivating students to attend the class and to understand and remember the content taught in class.
5. The videos has a somewhat positive influence in motivating students to apply the taught concepts beyond the classroom.

We list some ideas to use YouTube in the class.

1. Use YouTube videos to develop a hybrid class. Find YouTube videos that teach mechatronics concepts. Assign the videos to the students before they come to class. Then, use the class time for discussion and for problem solving.
2. Assign homework based on YouTube videos. The students watch YouTube videos and then answer homework questions based on these videos. We have tried this approach and have got positive reviews. Specifically, we assigned TED videos for homework assignments. Another idea is to ask students to watch YouTube videos at home and use the first few minutes of the lecture time to discuss the videos.
3. Ask students to search course-related YouTube videos and share it with the rest of the class (e.g., Liberatore [18]). This will have two effects: (i) Students learn about topics/concepts/application beyond the classroom. We believe that this will drive their curiosity in the subject matter. (ii) Students learn about a diverse set of applications by using the collective efforts of the whole

class.

4. Ask students to make YouTube videos (e.g., Yildiz [37] Manteufel [19]). This can follow the hybrid class examples. If the instructor is not able to find a video that explains a concept, the students can develop their own video for that concept. They could also re-make currently available YouTube video, if it is found deficient in any way. The availability of relatively cheap phones with built-in camera make this approach feasible.

References

[1] American Academy of Arts & Science. Taken as is from https://www.amacad.org/content/publications/pubContent.aspx?d=1111 (accessed: June 6, 2015)

[2] Arduino http://arduino.cc/

[3] Arduino Turn signal biking jacket https://www.youtube.com/watch?v=ZtNEPkwCfxA

[4] Arduino Cat water gun hack using a motion sensor and Arduino https://www.youtube.com/watch?v=lxmRYRlgreo

[5] Arduino Valentine's Heart Box https://www.youtube.com/watch?v=kXD4sUVdesU

[6] Blackboard Learn https://utsa.blackboard.com

[7] Biba Struja - electricity man https://www.youtube.com/watch?v=PhxG7MW7qUY

[8] Bonwell, C.C., and J. A. Eison, "Active Learning: Creating Ex- citement in the Classroom," ASHEERIC Higher Education Report No. 1, George Washington University, Washington, DC , 1991.

[9] Burke, S., Shonna Snyder, and Robin C. Rager. "An assessment of faculty usage of YouTube as a teaching resource." The Internet Journal of Allied Health Sciences and Practice 7, no. 1 (2009): 1-8.

[10] Clifton, Andrew, and Claire Mann. "Can YouTube enhance student nurse learning?." Nurse education today 31, no. 4 (2011): 311-313.

[11] Electric shock Prank - FUNNY ending https://www.youtube.com/watch?v=vKPVRi4ptcY

[12] Gas Station Fire, Static Electricity starts a flash fire https://www.youtube.com/watch?v=tuZxFL9cGkI

[13] Get Out Of Bed https://www.youtube.com/watch?v=izWCU4Y61o4

[14] Induction Loop Trick https://www.youtube.com/watch?v=bnMZ5d7oWi8

[15] Jaffar, Akram Abood. "YouTube: An emerging tool in anatomy education." Anatomical sciences education 5, no. 3 (2012): 158-164.

[16] Jimmy Kimmel Lie Detective #3 https://www.youtube.com/watch?v=P1cn8JHYLbU

[17] Knösel, Michael, Klaus Jung, and Annalen Bleckmann. "YouTube, dentistry, and dental education." Journal of Dental Education 75, no. 12 (2011): 1558-1568.

[18] Liberatore, Matthew W. "YouTube Fridays: Engaging the Net Generation in 5 Minutes a Week." Chemical Engineering Education 44, no. 3 (2010): 215-221.

[19] Manteufel, R.D., "Video Demonstrations Generated by Students in Statics", ASEE-GSW Annual Conference, South Padre Island, TX, March 28-30 (2007).

[20] Middendorf, Joan, and Alan Kalish. "The "change-up" in lectures." In Natl. Teach. Learn. Forum, vol. 5, no. 2, pp. 1-5. 1996.

[21] Mr. Bean - Car Park Chaos https://www.youtube.com/watch?v=SHvYDPWOVYY

[22] Mr. Bean - Hotel TV https://www.youtube.com/watch?v=fZfCecJ65CA

[23] Oceans Twelve - Capoeira Laser Scene https://www.youtube.com/watch?v=kUPQfzAyVeI

[24] Polleverywhere https://www.polleverywhere.com/

[25] Premkumar, Kalyani, and Cyril Coupal. "Rules of engagement-12 tips for successful use of "clickers" in the classroom." Medical Teacher 30, no. 2 (2008): 146-149.

[26] Prince, Michael. "Does active learning work? A review of the research." Journal of engineering education 93, no. 3 (2004): 223-231.

[27] Piano stairs - TheFunTheory.com - Rolighetsteorin.se https://www.youtube.com/watch?v=2lXh2n0aPyw

[28] Sheldon's theremin https://www.youtube.com/watch?v=_YYABE0R3uA

[29] Smith, Karl A., Sheri D. Sheppard, David W. Johnson, and Roger T. Johnson. "Pedagogies of engagement: Classroom-based practices." Journal of engineering education 94, no. 1 (2005): 87-101.

[30] Tan, Elaine, and Nick Pearce. "Open education videos in the classroom: exploring the opportunities and barriers to the use of YouTube in teaching introductory sociology." Research in Learning Technology 19 (2012).

[31] The Big Bang Theory - Prank Gone Wrong https://www.youtube.com/watch?v=psGe2Tc9g5Q

[32] This is NOT How You Catch an Electric Eel (Electrophorus electricus) https://www.youtube.com/watch?v=QCISeCZAFC8

[33] Trier, James. ""Cool" Engagements With YouTube: Part 1." Journal of Adolescent & Adult Literacy 50, no. 5 (2007): 408-412.

[34] Wankat, Phillip C. The effective, efficient professor: Teaching, scholarship, and service. Allyn and Bacon, 2002.

[35] Worlds Biggest Alarm Clock https://www.youtube.com/watch?v=kQ-l5PlDa-k

[36] Yada Backup Sensor System From Canadian Tire https://www.youtube.com/watch?v=ssCw3hCc7Bo

[37] Yildiz, M. 2007. Digital storytelling across cultures and throughout history date and time. Paper presented at the Society for Information Technology and Teacher Education International Conference, St. Louis, MO, June.

[38] www.youtube.com

PRANAV A. BHOUNSULE
Dr. Bhounsule currently serves as an Assistant Professor of Mechanical Engineering at the University of Texas at San Antonio (UTSA). He received his PhD degree in Mechanical Engineering from Cornell University in 2012. His research and teaching interests are in robotics, mechatronics, dynamics, and controls. He is the currently the faculty advisor for the ASME student chapter at UTSA.

RANDALL D. MANTEUFEL
Dr. Manteufel currently serves as an Associate Professor of Mechanical Engineering at The University of Texas at San Antonio (UTSA). He received his Ph.D. degree in Mechanical Engineering from the Massachusetts Institute of Technology in 1991. His teaching and research interests are in the thermal sciences. In 1999 he was awarded the Dow Chemical Outstanding New Faculty Award for ASEE Gulf Coast Southwest section.

Table 1. The survey questions and response percentage of all 52 students who took the survey. The columns are: SA, Strongly Agree (5 points); A, Agree (4 points); N, Neutral (3 points); D, Disagree (2 points); SD, Strongly Disagree (1 point). The points are assigned to each option in order to compute a numeric mean, which is shown in the last column.

	Question	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean
1	The in-class videos motivated you to attend the class.	18	23	11	0	0	4.14
2	The in-class videos increased your attention span in the class.	35	14	3	0	0	4.62
3	The in-class videos created a relaxing atmosphere in the class.	41	10	1	0	0	4.77
4	The in-class videos improved your attitude towards learning the subject.	29	15	8	0	0	4.40
5	The in-class videos increased your interest in the subject.	30	18	3	1	0	4.48
6	The in-class videos increased your understanding of the subject.	13	28	7	3	0	3.92
7	The in-class videos helped you to remember the content.	15	21	11	5	0	3.88
8	The in-class videos motivated you to apply the taught concepts outside the classroom.	21	20	10	1	0	4.17

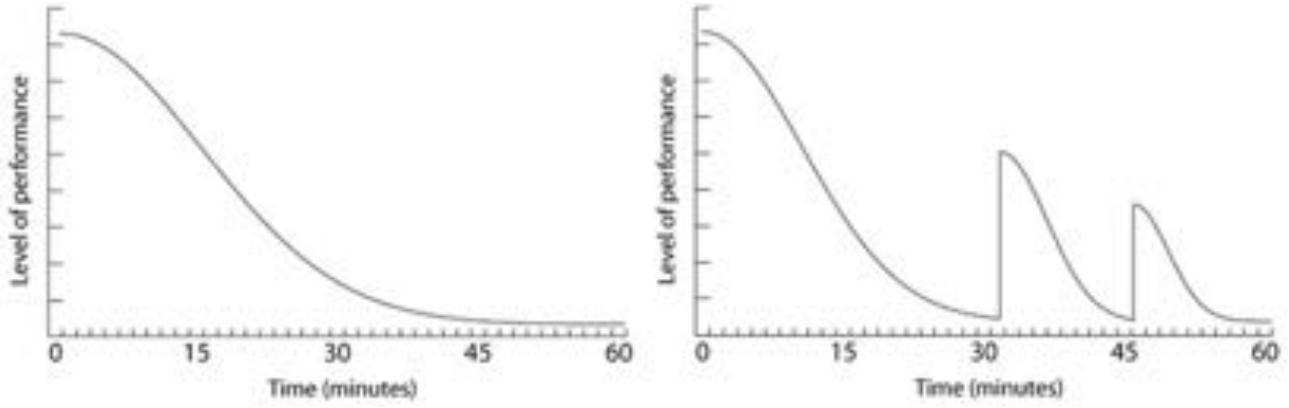

Figure 1. These two graphs measure students' relative level of performance as the fraction of students paying attention at any time as determined by twelve lecturers over an average of ninety lectures. The level of attention and performance during any lecture shows an almost immediate decline, and at the end of a class period of normal length (sixty minutes) attention is down to a very low level (left-hand graph). Interrupting the lecture for activities, quizzes, or asides helps (right-hand graph), but engagement never returns to what it was at the start of the class. Source: A schematic representation of the conclusions drawn by Johnson, A. H., and F. Percival. 1976. Attention breaks in lectures. Education in Chemistry 13:49–50. Credit: Taken as is from reference [1]

Figure 2. Students watching a video in the classroom.

Figure 3. Videos used to teach about induction loop sensors. (a) A person waving in front of the gate in order to open it. This strategy does not work because the gate does not use a vision sensor. (b) Video from My Bean [21] trying to trick the gate in opening. The videos in (a) and (b) were followed by explanation of an induction loop sensor. Next, we showed video (c) where a fire man slips a ladder in order to trick the induction loop sensor to open [14]. The trick is explained in (d). There is cutting in the road that has a wired loop. The ladder, which is metallic, changes the inductance of the loop thereby tricking the gate to open.