Higher Education Analytics: USABILITY RESEARCH OF ENGAGEMENT MEASUREMENT

TOOLS AND TECHNIQUES AND HOW THEY CAN BE ADAPTED FOR VIRTUAL

CLASSROOMS

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Abstract

With the increase use of technology in classrooms and the rise of online lectures, non-verbal cues that would help educators gauge how engaged their students are, are slowly diminishing. Real-time feedback, sent by students and received by lecturers, may provide insight to lecturers on how the students are doing and where improvement is needed in order to increase engagement in class. Surveys administered to university students on one existing real-time feedback technology, the use of clickers in lectures, as well as a video experiment conducted to research on feedback forms embedded in sample online lectures, can help reveal if real-time feedback is effective for improving lecture engagement and what formats and tools are the most effective. The research revealed that the existing mechanism of clickers does not improve engagement, but does motivate students to come to class. The video experiment revealed the value of free form feedback and the benefit of multiple choice questions relating to course content for students and professors alike.

Keywords: lecture feedback, online lecture videos, digital annotation, collaboration, video lecturing, interruption, quiz tools, educational feedback

Higher Education Analytics: USABILITY RESEARCH OF ENGAGEMENT MEASUREMENT TOOLS AND TECHNIQUES AND HOW THEY CAN BE ADAPTED FOR VIRTUAL CLASSROOMS

Engagement can be measured in various classroom settings. First, we review how often engagement should be measured during the learning process and how to strike the balance between gathering engagement metrics from students while minimizing distractions during their learning process. Second, we review how to motivate students to leave engagement feedback. After this, we review what physical form should be used for feedback, and the benefits and drawbacks of each. Lastly, we review the importance of collaboration and sharing engagement data. Judgements on the debates of collaboration on unsupervised quizzes, free form feedback versus content anchored feedback, and whether or not grading should be used as a form of motivation are all discussed. Analysis of the following can be used to make better judgements on how to gather engagement data in future learning environments in the most efficient and effective manner for both students and professors.

1   Engagement Measurement Frequency

When considering engagement tools and deciding on an engagement measurement technique for the classroom setting, many factors differ and must be taken into account on a case by case basis. One factor is how periodic the engagements should be measured. The more frequently the engagement of the students is measured, the more data there is to analyze and pinpoint how the learning experience can be improved. However, more frequent engagement measurements could have an effect on the learning process itself. Various studies have researched the effect of task-switching on the brain and the effectiveness of various alert modalities to signal to the user to switch tasks. A balance must be found, for measuring engagement in an educational setting often

enough that valuable feedback can be analyzed to pinpoint problems and improve future learning experience, while still ensuring that the action of measuring engagement does not interfere, distract, or diminish the learning process for students.

1.1 Task Execution Effect on Mental Workload

In the publication "Towards an Index of Opportunity: Understanding Changes in Mental Workload during Task Execution," (Iqbal, 2015) research was conducted to see how a user's mental workload changes during task execution. In classroom settings, intermittent quizzes or feedback forms can be useful for professors and instructors to pinpoint problems, however the effect of the task switching must be considered. When measuring engagement of students in a class setting, the effect of task switching between learning the material that is being presented and providing feedback on the material that is being presented must be taken into account. The research results reveal that "the opportune moment for interruption is during a period of low mental workload." (Iqbal, 2015 In the context of an academic lecture, this may be when the professor provides a break during the middle of the allotted class time, a transition from one slide to the next, or a pause in teaching where the professor asks the students how they are doing. In the context of an online academic class, this may be when a video ends, a module is done being discussed, or there is a transition to a new topic.

The overall takeaway from this research paper is the notion that not all tasks are created equal and all tasks vary in the amount of mental workload they require. Different tasks that may be needed in varying quantities based on the academic subject include cognitive work such as store, recall, and reasoning. For example, understanding comments and the document text require language comprehension. Making edits to a piece of writing requires language processing. Finding a file within a file system requires the cognitive process of recall.

This reflects how comprehension of a lecture is very much dependent on its content. For example, providing real-time feedback for a physics class may require more or less effort than providing real-time feedback for a philosophy lecture due to the varying mental work that each subject demands. Despite the content of the lecture, all lecture videos contain audio and visual elements. Due to the audio element of online lecture videos, most lecture videos require a fair amount of language comprehension cognitive workload. A one-way ANOVA analysis with subtask as a factor reveals that certain subtasks, such as reasoning, induces more mental workload than store, while other subtasks induce similar workload. For example, store and recall induce similar workload levels. (Iqbal, 2015)

1.2   Task-Switching Costs for Alert Modalities

While the act of task-switching and its effect on mental workload have been discussed, the physical form of the task-switching interruption has not been discussed. Interruptions to signal a task switch may come in different forms. While physical classrooms rely on organic task-switching mechanisms such as professors announcing a quiz, asking questions, or stopping to ask students if they have any questions, technologies that invoke pop-up in a video, sound, or vibrations can also be used in both physical and virtual classrooms. Due to the lack of a physical professor present, alert modalities are particularly significant in online classroom settings, such as videos.

In the publication "Alert in the Cleanroom: Testing Alerting Modalities for a Task Guiding Interface," (Strasser, 2013) various alerting methods are discussed for operators. The experiment was particularly invested in alerting an operator, but not diverting their attention completely from their task at hand. Although this experiment was aimed for alerting operators within the nuclear power, airplane maintenance, or semiconductor industry, the root design issue can also be applied to education. If students are alerted periodically to submit their engagement during their viewing

of the online lecture video, it shouldn't divert their learning of the material. The entire process of

gathering engagement data will cause more engagement problems instead of solving them. The

publication summed up this need for appropriate notification nicely with "on one hand such a

signal has to alert the operator, on the other hand it doesn't have to attract the attention too much

to divert the operator from the main work stream." (Glassman, 2015) In another research study

conducted, students and teachers were interviewed on their note-taking habits and some interesting

observations and findings were noted in regards to the effect of task switching to writing notes and

the effect on paying attention to what is being taught. The publication states, "all interviewed

persons stated that the formulation of a meaningful note requires a certain amount of concentration

which for a short time turns the attention away from the speaker. This could lead to spending more

time on taking notes instead of following the lecture and therefore missing important information."

(Grob, 2010)

The researchers experimented with various alerting modalities. These included screen-based task

interference, task guidance interference with ambient light, and tactile feedback. Results of the

experiment showed greatest impact of alarming for tactile feedback. The criteria for the greatest

impact is the "alarm should be clear and obvious. Second, it should not distract the operator

because an interruption of the current workflow cause task switch costs that may be

disproportionate to the benefit of alarming." (Glassman, 2015) Ambient light was also found to be

less effective in alerting compared to the vibrating wrist band. In fact, results showed that "the

vibrating wristband had the strongest effect and it was the fastest one in motivating our participants

to correct an error."

Based on these research papers, we can conclude that the frequency of engagement measurements

is not a fixed amount of time. Instead, the best approach is to interject engagement feedback forms

based on when there is a transition in the learning material because that is when the mental workload is reduced while learning. We can also conclude that tactile alerts, such as a vibrating wristband, has the strongest effect of task-switching. While current alert modalities in learning environments tend be in the forms of clickers, online quizzes, or popups in online videos, perhaps future education technologies will include wearables, such as a vibrating wristband. Another finding from the research to keep in mind during experimental design is that the process of writing diverts attention. This will be useful when deciding how and when to implement free form feedback modules to maximize on the value of engagement data, and minimize on distracting the student during the learning process.

1.3 Student Feedback Form Format

Engagement tools can come in many physical forms. Possible engagement form tools may include free form feedback responses, multiple choice question relating to lecture content, or annotations for lecture videos. Even within the annotations for lecture video content, there is a separation between time-stamped annotations or annotations that correspond to what is visually shown in the video lecture.

1.3.1 Free Form Feedback Engagement Mechanism

Free form feedback offers certain advantages and insights now how lectures can be improved for the future. In a research study, the muddy points systems that was originally used in physical smaller classrooms was applied to online lecture environments. Muddy points, in their original use, is feedback that each student leaves on an index card after a lecture. Muddy cards are "index cards that teachers give to students at the end of a lecture. Students are given time to reflect and write the "muddiest" (least clear) point on the index card to hand in as they leave." (Glassman, 2015) While this format works for smaller classes, physically collecting index cards for large

lecture halls is not a feasible option. As discussed in the article, "the aggregation of the responses in the index cards is often a time-consuming process." Due to this drawback, research was conducted on digitizing the muddy points feedback process. Students reported that the free form text box was especially useful when "muddy points are inherently non-spatial." This is further supported by the analysis that 36% of students like that they "could write down whatever they wanted." However, "28% of the students specifically mentioned the difficulty or tedium of expressing the muddiest point only through text "instead of just pointing to it." (Glassman, 2015)

1.3.2 Spatially-anchored Feedback

The study also covered the spatially anchored annotations. Mudslide, a web app version of the Muddy cards system, was built and analyzed in the publication. In the control version, a simple text feedback form is given at the end of the video. This is very similar to the manual Muddy Card system. In another version of Mudslide, students are asked to provide feedback during the video, but they must submit it with a corresponding slide. In a third alteration, student could click on a particular slide, as if they were pointing to a diagram or particular text on the slide, and leave feedback particular to that content rather than on the slide as a whole. Students preferred the spatial slide-specific annotation over the free form box is because the "it was much easier to provide the muddiest moment when I had the visual cues to help remind me what they were." Qualitative feedback on the student interface revealed that overall, students like the ease and exactness of leaving feedback for particular slide. However, "requiring a spatial anchor for each muddy point affected the process of commenting on non-spatial aspects of the video."

Students, overall, preferred the spatially anchored feedback over the free form feedback. Hence, the conclusion can be made that the free form text box provides flexibility and freedom, but also requires a bit more effort for analysis. The main drawback of the spatially anchored feedback

analysis, however, is the flexibility of leaving feedback on what is said versus what is shown. As noted in the publication, "16% of students described wanting to "point" to a moment in time or to what was being said over the slide, instead of the text or images on the slide." This indicates that what is missing from Mudslide is the ability to indicate a confusion that is related to what is being said in an online lecture video, rather than what is being shown. In fact, "one student remarked that this was especially problematic when teachers spent a long time talking over a slide with little information on it." Teachers reported that "although Mudslide's visual point-and-click interface was suggests of spatially-oriented feedback, many students nonetheless provided feedback on non-spatial and/or holistic aspects of the lecture."

This paper reviewed engagement tools and methods that can be applied to virtual classrooms and learning environments, emphasizing what has worked in the physical environments and how they can be adapted for virtual ones. While it is not likely or currently feasible that wearables will be used to alert students to an online quiz or alert them to leave feedback, other research, such as the Muddy Points system adapted for video technologies, served to be a promising basis for engagement feedback for future online classrooms. While engagement tools and methods have been researched, most of the focus has been on students. Future research should be aimed at the feasibility of such technologies and how professors can setup, gather, and analyze the engagement feedback effectively and easily. Even if the technology tools exist, if they are not easy to set up by the instructors or professors, the engagement feedback will never be gathered. Future research should also be aimed at comparing and contrasting physical and virtual classrooms. While the lack of nonverbal communication has been acknowledged, and we have reviewed how to overcome this disadvantage in this paper, there could be other drawbacks of virtual classrooms and learning environments that will also need analysis so that the proper solutions can be found.

2   Methods

2.1   Hypothesis

The experiment and survey results sought to determine the validity of the following hypotheses:

H1: The feedback format is significant in measuring student engagement for lectures and

providing professors insight into where improvements can be made

H2: The frequency of engagement measurements is significant for pinpointing where

improvements can be made.

2.2   Subjects

The experiment was carried out by 41 volunteer participants. All participants were undergraduate

students at Northeastern University. The students came from a diverse academic background. The

41 participants broke down to 21 females and 20 males by gender, and comprised of at least 1

participant from each college (3 health science, 5 design, 16 computer science, 7 engineering, 5

sciences, 3 social sciences, 2 business) and one from each year. The participants received

compensation in the form of discounted Easter candy.

Apart from the video experiment, interviews were also conducted. Surveys were distributed to

professors at Northeastern University who have used Turning Point Clickers in their classes.

Records of professors that use Turning Point Clickers at the university were obtained from the

Academic Technology Services office. Survey results were gathered from 8 professors from

various colleges. Out of the 7 colleges at the university, the survey results from the professors

represented 5 colleges (5 health science, 1 design, 1 computer science, 1 engineering, 5 sciences).

Another survey on Turning Point Clickers was also distributed to undergraduate students at

Northeastern University. 56 survey response were gathered and every college was represented by

at least 1 student response (4 health science, 5 design, 16 computer science, 7 engineering, 5

sciences, 3 social sciences, 2 business). Out of the 56 responses, further questions on clicker use were asked to those who answered 'yes' to having used a clicker at a college class (33 yes, 23 no).

2.3   Apparatus

A web player software service, HapYak, was used for the experiment. In the experiment, participants were asked to watch a video that consisted of three different segments. At the start of the video, after each segment, and at the end of each video, participants were asked questions. HapYak was leveraged to include questions embedded in the player at the end of each segment, and the HapYak portal was leveraged to gather to raw data of the participants' responses. The video segments used in the HapYak player were collected from YouTube. Due to the research and educational purpose for the copying of the videos, the final video used in the experiment is protected under fair use. Google Forms was another service leveraged to distribute surveys and gather survey results. One survey was designed for students (see Appendix M) and separate survey was designed for professors (see Appendix N).

2.4   Experimental Design

The experiment used a test video that comprised of three different segments. Each segment was independent of one another, much like academic modules. The content of each segment was 3 minutes of an academic lecture. Each segment varied the level of the academic lecture that was used, however, all three segments consisted of STEM related academic content. This was done due to the research found on varying mental workloads demanded for different subjects. In order to keep attention span and mental workload constant in the experiment, each segment was approximately 3 minutes long, and each segment has similar academic content. One segment was academic content pertaining to anatomy and was aimed for children, to represent academic content that college students would find too easy. Another segment had academic content pertaining to

chemistry, but targeted at older students. The quality of the segment included clear audio and visuals, diagrams, and a couple of animations. The last segment has academic content pertaining to physics. The visual and audio quality was mediocre.

General questions were included at the beginning of each video. Three questions aimed at measuring engagement were also included at the end of each segment. One question was a free form feedback in which the student could write whatever they wanted. Another question was a multiple choice pertaining to how the student felt when they watched the video segment. The third question was a multiple choice question pertaining to the academic content of the video. The video segments with easy and medium academic level content did not raise any issues when creating a multiple choice question pertaining to academic content. When creating the multiple choice question for the hard video segment, a physics PhD candidate was consulted to ensure that a proper and fair multiple choice question was included.

To ensure and to analyze that the ordering of the video segments did not affect the research results, 6 videos were created to reflect all possible six combinations of the three lecture video segments. When participants were asked to watch a video, they were randomly served 1 of the 6 videos to watch. (see Appendix L) Angular.js was used to randomly serve a HapYak player with a different video on every page load (see Appendix M). This ensured that for each participant, a different video was loaded. By clicking the link, they were randomly served 1 of the 6 videos.

2.5 Procedure

The research study videos were distributed via a webpage on various university social media groups. Participants were also gathered by approaching them on campus in various popular study areas. Since most online lectures for a university class would be watched by students where they do all their other homework, it made sense to approach participants and administer the research

study at popular study spots such as the student center, on-campus coffee shop, and library. It was

observed that not only using authentic study locations was important, but also the authentic

studying experience is important. Some student participants were approached while eating, talking

to friends, or simply sitting alone and working on coursework as seen in **Error! Reference source

not found.**.

Figure 1: Student Participants take the Video Experiment in Usual Study Environments on Campus

The participants were asked to watch the video and treat it was if it were an online lecture video

class. The video started with a few questions (See Appendix A). After the beginning questions, the

first segment plays and then more questions pop up. The participant must fill out three questions

before proceeding to the next video segment. The first question pertains to academic content of

the video segment in the form of a multiple choice answer (see Figure 2), the second is a free form

textbox in which the participant can write anything they want (see Figure 3), and the third question

is a multiple choice question related to the participant's viewing experience (see Figure 4).

Figure 2: Example of Multiple Choice on Academic Content Mandatory Pop-Up Module
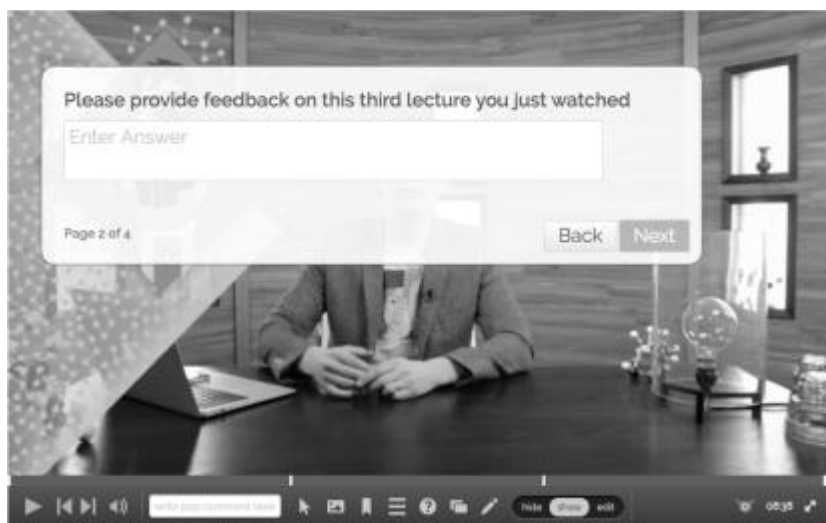

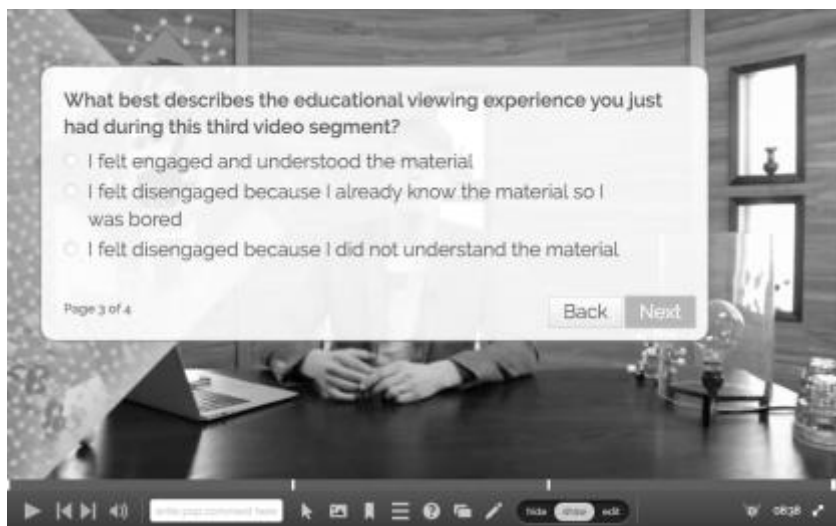*Figure 3:Example of Free Form Textbox Mandatory Pop-Up Module*

Figure 4: Example of Multiple Choice on View Experience Mandatory Pop-Up Module

After the three video segments have been viewed and their respective feedback questions have been answered, a final set of questions are asked to the participant. Each of the video segments was roughly 3 minutes of a lecture. With the viewing and filling out of the the questions, each participant took roughly 12 to 15 minutes to complete the video experiment.

The survey portion of the experiment was conducted by sending out google forms to both students and the professors listed on the Northeastern University Academic Technology Services as registered for Turning Point clickers.

3   Empirical Results

The HapYak dashboard and Google Forms dashboard were used to gather the data collected. The data sets were transcribed to .csv that were then evaluated for analysis using R Studio.

3.1   Quantitative Data

3.1.1   From the video questions

As mentioned earlier, a total of 41 participants took part in the lecture video portion of the research. All participants were undergraduate students at Northeastern, and a breakdown by college can be seen in Table 1 and **Error! Reference source not found.** below. Of the 41 undergraduate Northeastern participants, there was a relatively even distribution by gender, at 21 females and 20 males as seen in **Error! Reference source not found.**. Each participant was randomly served a video to watch. All videos contained the three same segments, but in different order. The videos with the lecture segments in 'hard, medium, easy' order, 'hard, easy, medium' order, 'easy, hard, medium' order, 'easy, medium, hard' order, and 'medium, hard, easy' order were all watched by 7 participants each. The video with lecture segments 'medium, easy, hard' order was watched by 6 participants. Breakdown of all the videos by segment ordering combination and the number of participants for each can be viewed in Table 2.

After each video segment, a multiple choice question pertaining to the academic content included in the segment that the participant just viewed was asked. For the 'easy' lecture segment, 100% choice the correct answer, legs. For the 'medium" lecture segment, 78.6% of the 41 participants chose the correct answer 'r group'. For the "hard" lecture segment, only 21% of the 41 participants chose the correct answer 'gravity'. A chi-square test for independence revealed that the participants' likelihood of answering the multiple choice question based on academic content is independent of the ordering of the lecture segments in the video. Due to the frequency of zero incorrect multiple choice answers for the 'easy' lecture, chi-square evaluations could not be done. For the 'medium' and 'hard' lecture multiple choice questions, p values greater than .05 concluded that segment ordering and correctness of multiple choice questions based on academic content are independent.

Table 1: Participant Breakdown By College

College	Number of Participants
Bouve	3
CAMD	5
CCIS	16
COE	7
COS	5
CSSH	3
D'AMORE-McKim	2
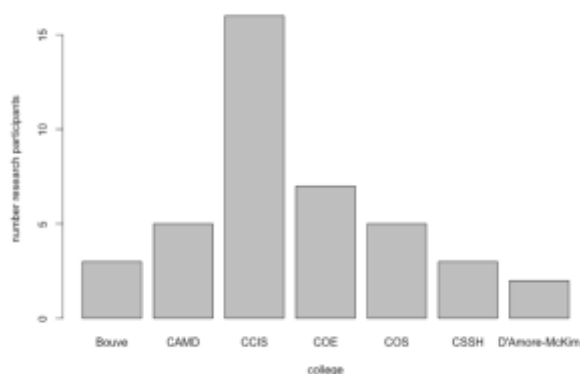
Figure 5: Participant Breakdown By College
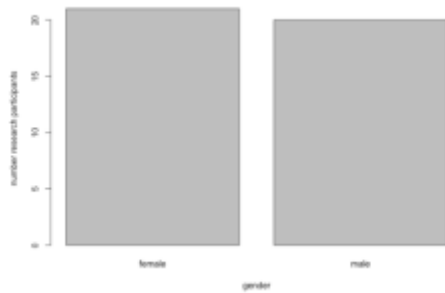
Figure 6: Participant Breakdown by Gender

Table 2: Participant Breakdown by Video

Videos by Lecture Segment Order	Number of Participants
Hard, Medium, Easy	7
Hard, Easy, Medium	7
Easy, Hard, Medium	7
Easy, Medium, Hard	7
Medium, Hard, Easy	7
Medium, Easy, Hard	6

After each video segment, a multiple choice question related to the viewing experience was also

asked. For the 'easy' lecture video segment, 26.8% of the participants felt engaged and understood

the material, 65.85% reported they felt disengaged because they already knew the material so they

were bored, and 7.3% of the participants felt disengaged because they did not understand the

material. A break down by number of a participants for each multiple choice answer can be viewed

in Table 3 and **Error! Reference source not found.**.

Table 3: Multiple Choice Answers on Viewing Experience for Each Segment

Video Segment	I felt disengaged because I already know the material so I was bored	I felt engaged and understood the material	I felt disengaged because I did not understand the material
Easy Lecture	27	11	3
Medium Lecture	1	35	5

Hard Lecture	0	8	33
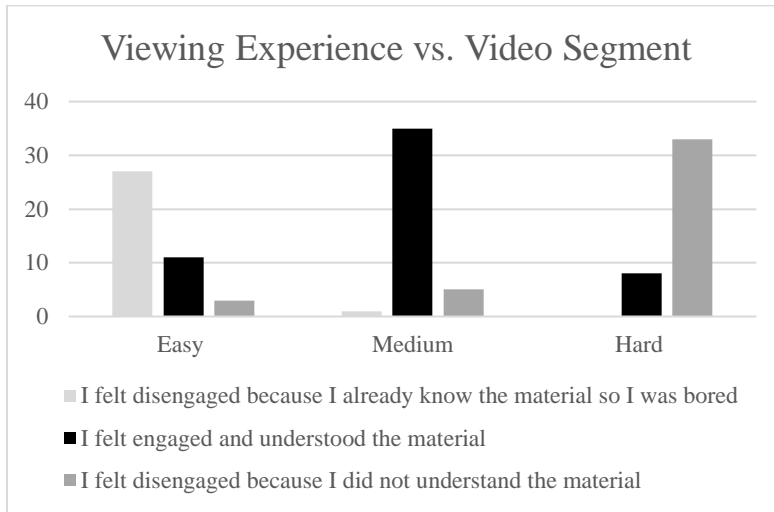
Figure 7: Multiple Choice Answers vs. Video Segment

At the end of the video, all participants were asked to indicate which of the three forms of feedback they liked the best: free form feedback, multiple choice question on viewing experience, or multiple choice question on academic content of the segment. As seen in Table 4 and **Error! Reference source not found.**, 17 participants preferred the multiple choice question on lecture content, 20 liked the free form textbook the best, and 4 liked the multiple choice question on viewing experience the most.

Table 4: Participant Answers for Preferred Feedback Form

Preferred Feedback Form	Number of Participants
mc question on lecture content	17
free form feedback text box	20
mc question about how I felt	4
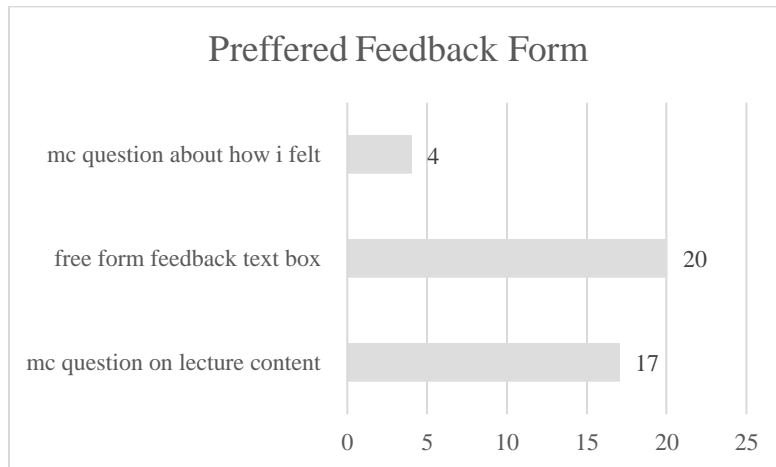
Figure 8: Plot on Frequency of Participants' Preferred Feedback Form

Student were also asked what video segment they found the most engaging. 35 participants found the 'medium' video segment most engaging, 6 participants found the 'easy' video segment most engaging, and 0 participants found the 'hard' video segment most engaging (**Error! Reference source not found.**).
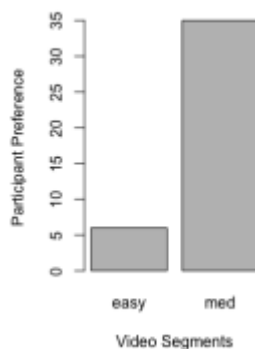
Figure 9: Most Engaging Video Segment for Participants

When asked the reason for why it was the most engaging, students were either allowed to pick one from a list or provide their own answer. Out of the 41 participants, 4 elected to write out their own answer. As seen in **Error! Reference source not found.** and Table 5, 4 students picked 'the audio was clear' as to why the video segment they chose was the most engaging, 10 participants cited

because "There was use of animation", another 10 participants chose "There was use of images",

4 participants chose "I learned something new", and 9 participants chose "The use of diagrams".
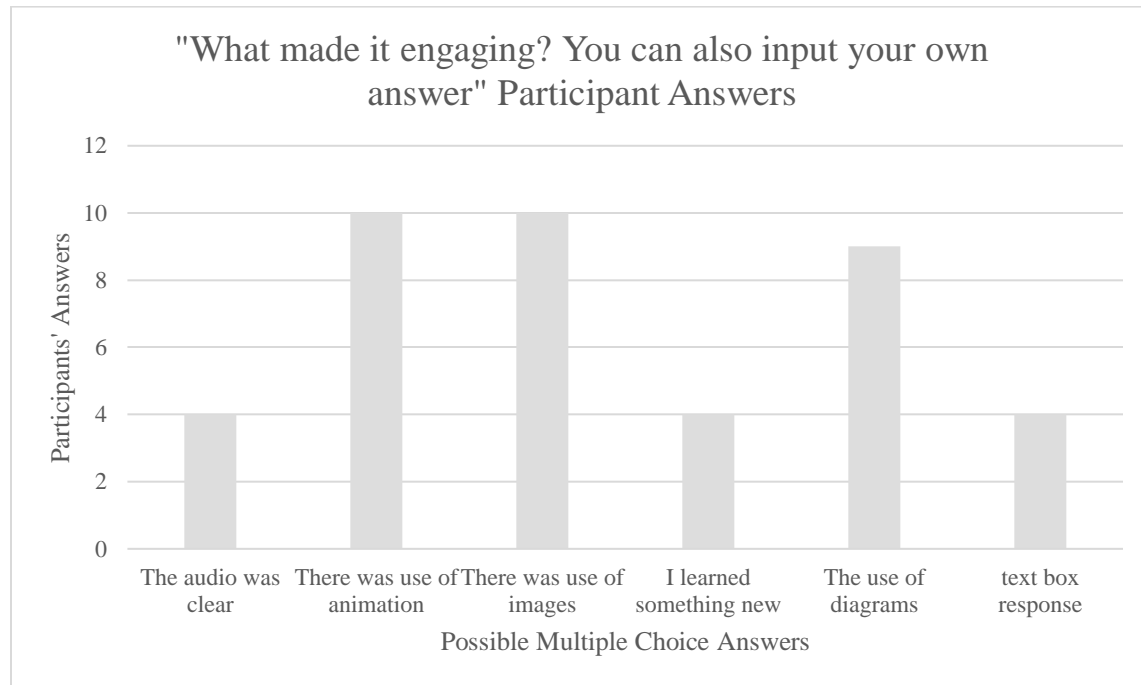
Figure 10: Reasons Why a Video Segment Was Found to Be Engaging

Table 5: Reasons Why a Video Segment Was Found to Be Engaging

Multiple Choice Options	Participants
The audio was clear	4
There was use of animation	10
There was use of images	10
I learned something new	4
The use of diagrams	9
text box response	4

Students were also asked if they would like to see the responses of their classmates to the lecture

questions. A modified likert scale was used to measure the participants' desire to view their peer

responses with the options agree, disagree, and indifferent. As seen in **Error! Reference source**

not found., the mode is 17 participants who voted for 'disagree.' Students were also asked how

they feel about their multiple choice answers being calculated into their grade for the class. The

mode was at 16 participants who answered "this would motivate me to pay attention in class."

Frequencies for other responses can be seen in Table 6 and **Error! Reference source not found.**.

Undergraduate students who participated in the study were also asked if they would like to see if

their own responses on the multiple choice questions related to academic content were correct or

not. As seen in **Error! Reference source not found.** and Table 7, the mode of the answer was

'Indifferent' with 23 participant votes.
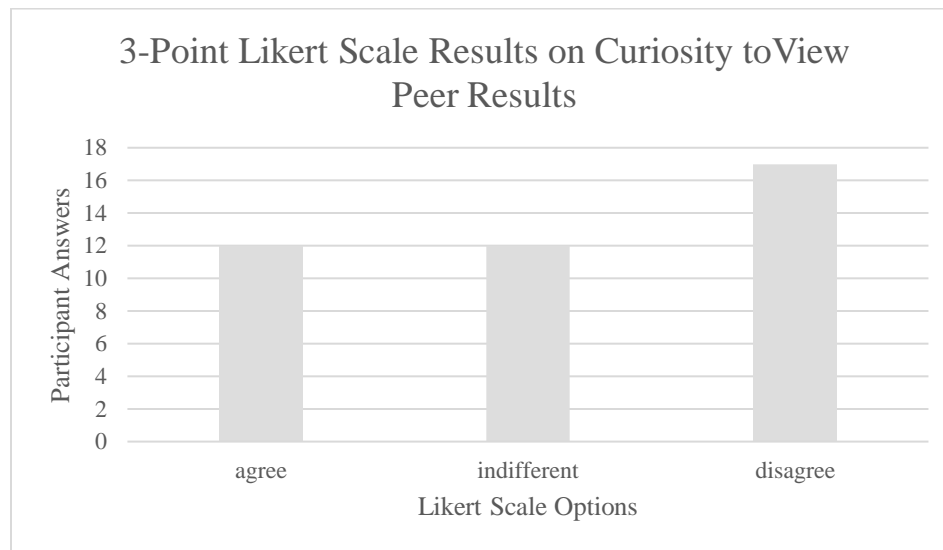
Figure 11: 3-Point Likert Results on Curiosity to View Peer Results
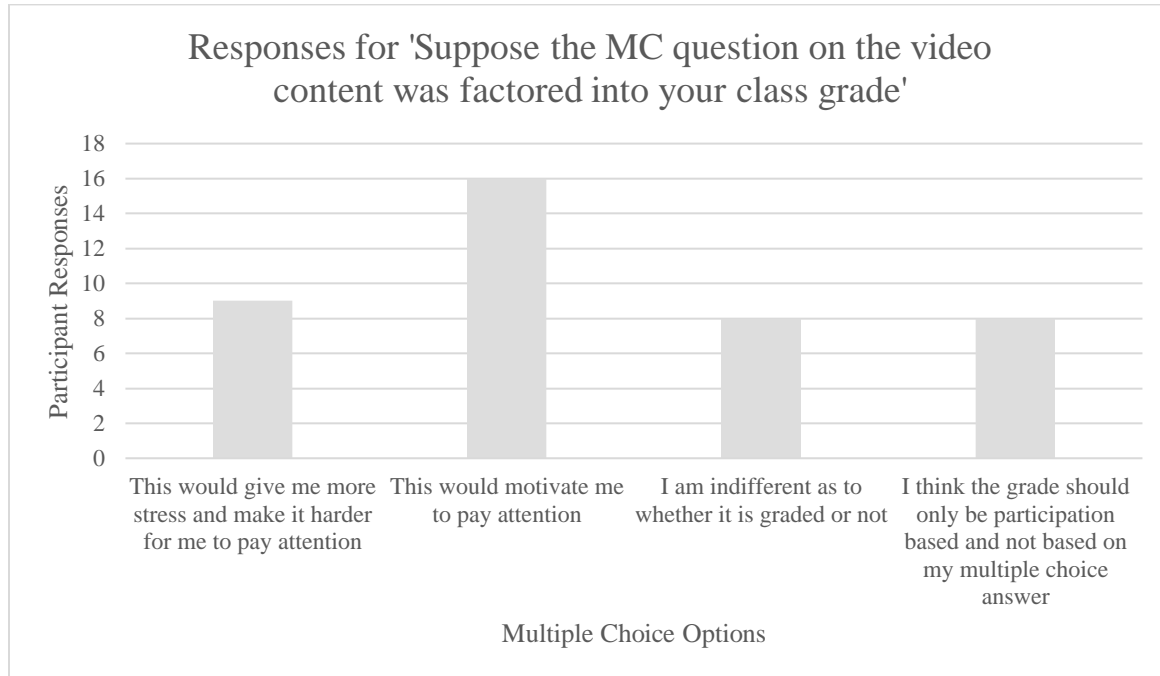
Figure 12: Responses on Factoring MC Answers in Class Grading

Table 6: Responses on Grading MC Answers Related to Academic Content

Multiple Choice Options	Participant Responses
This would give me more stress and make it harder for me to pay attention	9
This would motivate me to pay attention	16
I am indifferent as to whether it is graded or not	8
I think the grade should only be participation based and not based on my multiple choice answer	8

**'I am curious if I got the multiple choice
questions right. I would like to see my answers'
MC responses**
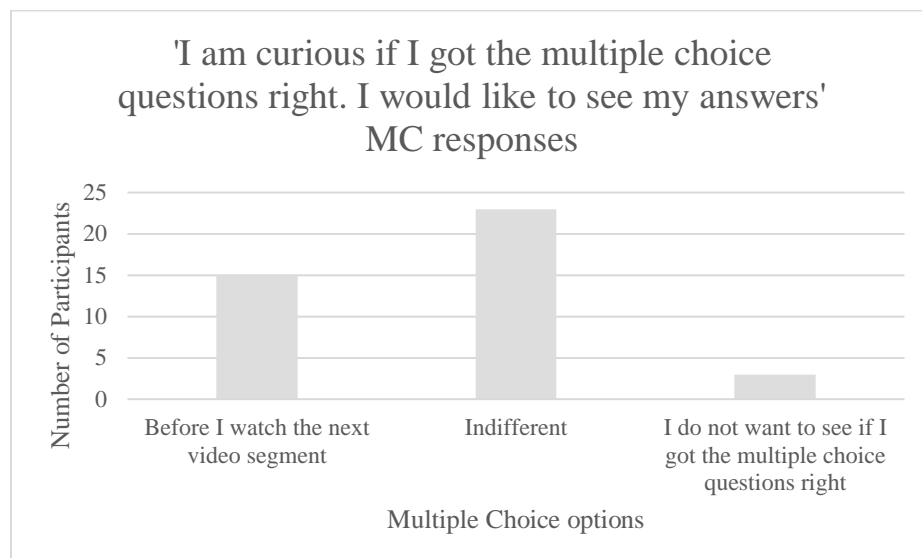
Figure 13: Participants' Curiosity on Viewing the Correct Answer

Table 7: Participants' Curiosity on Viewing the Correct Answer

'I am curious if I got the multiple choice questions right. I would like to see my answers…'	Participant Responses
Before I watch the next video segment	15
Indifferent	23
I do not want to see if I got the multiple choice questions right	3

3.1.2   From the clicker surveys to professors

The electronic clicker survey that was created using Google Forms was sent out to all the

Professors at Northeastern who had at some point used clickers in their classes. Emails of the all

the teachers at Northeastern who adopted clickers were gathered from Northeastern Academic

Technology Services. 8 professors responded (5 Bouve College of Health Sciences, 1 College of

Arts Media and Design, 1 College of Computer and Information Science, 1 College of

Engineering). 6 of the 8 professors reported that the clicker answers were factored into the

students' grade. 3 reported that the clickers were mainly used as an attendance mechanism to sign

into class. 7 reported that the clickers were used to quiz students on class material. Clicker use was

found to be used at the beginning of class by 87.5%, at the end of class by 62.5%, and in the middle

of class by 75%.

Many answers were also gathered using the likert scale as a form of measurement. On a 5-point

likert scale, 100% of the professors learned towards 'agree' for the prompt, "in order to be the

most effective, clicker quizzes should be on material covered in class." On a 5-point likert scale,

100% of the professors also learned towards 'disagree' for the prompt, "In order to be the most

effective, clicker quizzes should only be used for attendance/participation grading." For "Clicker

quizzes on class material helps me realize how well my students understand the material" 1

professor leaned towards disagree, 1 reported neutral, and the 6 leaned towards agree. "Using

Clicker Quizzes has made me a more effective lecturer" showed more responses towards the agree

spectrum, but 1 professor responded towards disagree, and 1 reported neutral. 6 out of the 8

professors rated a 5 for agree on a 5-point likert scale for "I feel that clicker quizzes help my

students focus in class and prevent them from zoning out." The mode response was a netural-3

with 5 professor responses for "Clicker quizzes on class material should be graded." "Using clicker

sign-ins for lecture attendance points is effective and motivates students to come to class," saw a

relatively even distribution of answers on the 5-point likert scale. 5 out of 8 professors rated a 5

towards 'agree' for the prompt "I feel that clicker quizzes help me understand what concepts

students were struggling to learn." When asked their opinion on when clicker quizzes should be

administered in class, "at the beginning of class to review where we left off" received 6 votes.

"More than three times during class" and "at the end of class to summarize a lecture" tied for the

mode at 7 votes each.

3.1.3   From the clicker surveys to students

A clicker survey was distributed using Google Forms via Northeastern related Facebook groups. Out of the 56 participants who filled out the survey, 33 (58.9%) of the participants were in College of Computer and Information Science. 33 of the 56 answered 'yes' to having used a clicker at some point during their undergraduate education at Northeastern. Those who responded with 'yes' were asked more questions about their clicker experience. Out of the 33 respondents who had used clickers before, 28 answered that the clicker questions were inculcated as part of their class grade. 45.8% said they were used to sign into class, like an attendance sheet, and 81.8% said they were used to quiz on class material. The clicker quizzes were reported to occur at the beginning of class (66.7%), in the middle of class (63.6%), but rarely at the end of class (36.4%). When asked "In order to be the most effective, clicker quizzes should be on material covered in class," participants leaned towards agree with 17 votes for 'strongly agree' and 10 for 'agree.' The mode for "In order to be the most effective, clicker quizzes should only be used for attendance/participation grading" was a neutral 3 with 10 participant votes.

While no strong skews were seen on the opinion of "I felt that clicker quizzes helped me focus in class and prevent me from zoning out," or "Clicker quizzes on class material should be graded," most did agree that "Using clicker sign-ins for lecture attendance points is effective and motivates me to come to class." Generally, it was also agreed upon that "I felt that clicker quizzes helped the professor understand what concepts students were struggling to learn." Students reported that they zone out in class only when they are bored.

3.2   Qualitative Data

3.2.1   Video Experiment Questions

3.2.1.1   *Free form Feedback*

After each of the lecture video segments, students were asked to fill out a free form textbox with feedback. The prompt, as seen in **Error! Reference source not found.** was very vague with "Please provide feedback on this [first, second, third] lecture you just watched." Generally, the response for the 'easy' lecture for the freeform feedback included comments on how boring the lecture was, comments on the background music, and how repetitive it was. While generic comments were made about the content, such as "boring" or "for kids", only two feedback entries cited actual academic content from the video specifically. The same can be said about the "medium" lecture free form feedback. Many comments were made about the nice use of visuals and the lecturers' ability to speak well. 2 feedback entries also compared it to the segment they had previously watched, and said it was better than the first segment they watched. The 'hard' lecture free form feedback mainly included comments on the quality of the audio and visuals in the lecture and how they wished it was better, had trouble hearing, or could not read what was written on the whiteboard. (See Appendix F) While only some feedback entries made comments about the visuals and how it was hard to read what was on the board, most entries included feedback on the audio and how it was difficult to hear.
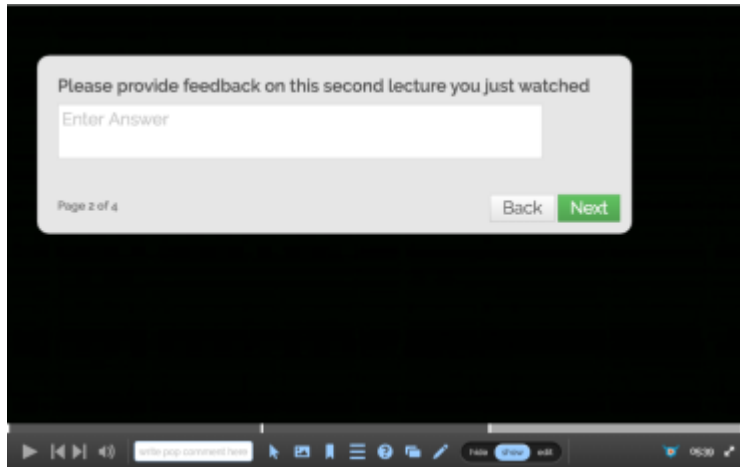
Figure 14: Screenshot of Feedback Form Module from Video Experiment

3.2.1.2   Preferred Feedback form

We have already covered the relative frequency of the multiple choice question related to academic content, free form feedback text box, and multiple choice question about viewing experience in terms of preferred feedback form for participants. After being asked their preferred form, participants were then asked why that was their preferred form. (see Appendix C)

Generally, those who chose the multiple choice question related to academic content as their preferred feedback form explained it was their preferred form because it was a quick and efficient way to tell if they actually were learning the material. Those who chose the free form feedback text box said it was their preferred feedback form because it was nice not be constrained and write down whatever they wanted. One feedback entry also included that the free form feedback felt less stressful than a multiple choice question. "Multiple choice questions about how I felt" had the lowest relevant frequency for preferred feedback form. Generally, it was chosen because it was a quick and low effort way to communicate if the participant understood the content of the video. One participant wrote down "I'm not quite sure why…" as their reasoning for choosing it as a preferred feedback form.

3.2.1.3   Most Engaging Video Segment and its Characteristics

After participants were asked to pick which of the three segments in the video they found most engaging, the 'easy' lecture, 'medium' lecture, or 'hard' lecture, they were asked "What made it most engaging, you can also input your own answer." As seen in **Error! Reference source not found.**, 4 participants elected to input their own answer instead of picking one of the options. Reasons for why the video segment was found to be engaging include humor, use of multimedia, clear audio, and interesting subject matter. All users who elected to input their own answers reported the 'medium' lecture segment as the most engaging. Table 8 includes the raw data from the free form answers inputted by the research participants.

3.2.2   From the clicker surveys to professors

The clicker survey, that was distributed via email to all the Northeastern professors that had used a clicker in their class, included a couple of free response questions. For the survey question, "How can you tell if students are zoning out in class? What are some nonverbal cues that indicate a student is not paying attention in lecture?" professors generally responded with the reasons: they are not making eye contact, they are looking at their computers, they are getting up, sleeping, or asking the same question multiple times. (See Appendix G) When asked, "How would you compare your lecturing experience before and after the use of clicker quizzes? In what ways has it improved?" professors generally responded with that here was increased engagement, attendance, and student performance. Of the 8 professors that filled out the survey, one recorded that the lecturing experience had not improved for them. The general responses for "How have students felt about the use of clickers in your class? What has been the general feedback" were that the student liked it. Some noted that the expense of the clickers and the fact that clicker points are tied to their grade were the causes why some students did not like the clickers. (see Appendix I) For

"What type of clicker questions have you found to be the most effective?", most professors responded with multiple choice, one did not understand the question, and one responded with both multiple choice and true false. (see Appendix J) For "What type of clicker questions have you found to be the least effective?", professors mostly responded with "none" or not applicable, one cited they did not understand the question, one cited short answer and essay questions, and one cited generic questions.

4   Discussion

4.1   Clicker Surveys for Students and Professors

The clicker surveys were distributed electronically and the responses were analyzed before designing and conducting the video experiment. Different clicker surveys were designed for a students and professors, but some of the questions were intentionally left similar so that comparisons could be made. The breakdown of the participants for the student clickers is not representative of the distribution of the population. While 33 participants of the student clicker quiz were in the College of Computer Science, the college is one of the smallest in terms of population at Northeastern. However, the distribution of the professor clicker survey responses is more representative of the population, as only Northeastern Professors who had registered and ever actually logged into their Turning Point Clicker accounts were contacted about participating in the study.

Many comparisons can be made from comparing and contrasting the survey results between students and professors. While 57.9% of the student responses were from computer science students, 62.5% of the professors' responses were from the college of health sciences. Professors and students both believe in a similar objective for what clicker quizzes should be used for. When asked "In order to be the most effective, clicker quizzes should be on material covered in class,"

both students and professors overall leaned towards agree on the likert scale. While all the professors surveyed leaned towards disagree for "clicker quizzes should only be used for check-in purposes, 3 professors reported just using it for attendance purposes. This suggests that while there is a belief that clicker quizzes and real-time feedback has value, it is not always implemented in a way that follows the beliefs. This could be for a variety of reasons, but one reason may be that professors do not have enough time or energy to devote to setting up real-time feedback. Follow up interviews with these 3 professors from the survey can be conducted to find out for certain why they only use the clickers for attendance and why is hindering them from using it for quizzing academic content.

Students and Professors both reported with highest frequency that clicker quizzes are administered at the beginning of class. The second highest frequency reported clicker quizzes in the middle of class. Both students and professors reported clicker quizzes at the end of class were the least frequent. Professors and students had split views on grading clicker quizzes. When asked, "In order to be the most effective, clicker quizzes should ONLY be used for attendance/participation grading," 87.5% of the professors reported 'highly disagree' on a 5-point likert scale, while the mode for students was 30.3% who voted a neutral 3 on a 5-point likert scale. Interestingly, students and professors differ on their options of clicker quizzes and their usefulness in increasing focus. No clear consensus was seen on students' opinion on "I felt that clicker quizzes helped me focus in class and prevent me from zoning out," but 75% of the professors strongly agreed that clicker quizzes keep their students focused. This reveals that there may be a misuse in how the clickers are actually used versus how educators envisioned them being used. It also reveals that the engagement data collected by professors, usually multiple choice answers relating to class content, may not be a good indicator of engagement. From in-person observation of a rock class,

it was noted that clicker quizzes do not keep students from multi-tasking. Since some of the questions were only worth participation points, students tend to only pay attention around quiz time. However, when asked, "Using clicker sign-ins for lecture attendance points is effective and motivates me to come to class," most students (14 participants, 42.4%) responded with agree. Even though clicker quizzes do not seem to improve attentiveness of students, it does motivate them to actually show up to class.

Students and professors both agree that the use of clickers improves realization and communication about the pace of the class. For "Clicker quizzes on class material helps me realize how well I understand the material," 11 students responded with "agree" on a 5-point likert scale, yielding a mode of 33.3%. Students also generally lean towards agree that "I felt that clicker quizzes helped the professor understand what concepts students were struggling to learn" and majority of the professors surveyed, 62.5%, that the clicker quizzes help them realize how well students understand the material they are presenting.

Students and professors alike were both asked if they felt lecturers were more effective with the advantage of real-time feedback as opposed to not using clicker quizzes in lectures at all. Very different views were seen on this matter. While most surveyed students (15 participants, 45.5%) reported neutral for "Professors are more effective when they use clicker quizzes" and 10 participants (30.3%) reported 'strongly disagree', 6 of the 8 professors surveyed felt they were more effect when they use clicker quizzes. While this raises many questions, more in-depth interviews may need to be done to see what students are comparing on. Are non-clicker lectures any different than clicker lectures? Based on the free form response in which professors were asked to elaborate how the lecture experience has improved. A reason why students may not see professors as more effective is perhaps they have no baseline to compare it to. Since they only

have professors on a semester to semester basis, a comparison may not be done. Since no questions
in the survey could be left blank, students picked neutral as the best option. Professors measured
improved experience by TRACE evaluations, seeing their students challenged, improved student
performance, and attendance.

4.2   Video Experiment

The online video lecture experiment that was conducted with the help and participation of
undergraduate students was similar to Mudslide, the web app version of the Muddy cards system
discussed earlier, in many ways. Just like in Mudslide, students could also leave free form feedback
in the video experiment after each lecture segment. However, the setup is slightly different since
Mudslide focused on spatially anchored annotations while the video experiment annotations were
evenly divided popup modules after each video segment. Based on the research on task switching
costs, alert modalities were placed at the beginning and end of each of the lecture segments, where
the least amount of learning is happening and the task switching cost is the lowest. Hence, the
engagement measurements were more audio anchored than spatially anchored in the experiment.
One interesting observation from the video experiment is that for the "easy" academic content
lecture segment, 26.8% of the participant felt engaged and understood the material. This may
allude to the finding that academic content difficulty is not the only factor in video engagement.
While more students felt engaged for the "medium" lecture segment, which has chemistry concepts
that would be covered in a college course, a number of participants still found the "easy" lecture
segment reviewing body parts to be engaging as well, even though the lecture content was probably
a review.

The three different video engagement measurements also yielded different results. While multiple
choice based on academic content did reflect the level of academic difficulty of the segment, the

free form feedback provided the most information on the video quality. Many students wrote

down, for example, that it was difficult to hear or see the board in the "hard" lecture video.

5   Conclusion

Based on the research, the hypothesis can be accepted that feedback format is significant in

measuring student engagement for lectures and providing professors insight into where

improvement can be made. Multiple choice based on academic content was found to be the most

effective in determining if students understand the material being relayed by the professor. Free

form feedback allows students to comment on the overall quality of the lecture, such as audio and

visual components.

Based on the research, H2 can also be accepted. Frequency of engagement measurements is

significant for pinpointing where improvements can be made. Professors reported increased

engagement and ability to improve their lecture quality from adapting clicker technologies. These

quizzes provided feedback on the course sooner than the end of the semester TRACE evaluations

that students can opt to leave for a class.

5.1   Relevance of Findings

Outside of the context of this research experiment, the relevance of the findings from the study can

be applied to the various existing as well as future classroom engagement technologies. What this

study revealed is that engagement is not necessarily tied to just academic content. Many factors

make a video engaging, particularly video and audio quality and presentation. The study also

revealed different mechanisms that can be used to measure engagement and how they differ. While

free form feedback allows the freedom to leave comments about the video quality, free form

feedback is also harder to aggregate.

It can also be concluded that engagement tools actually do not help to increase student engagement, but rather they help in accurately measuring it. They do help in relaying information and opening the communication from students to professors. Even the effort to use grading as a way to engage students can be misdirected, and actually hinder the learning process. Multiple choice answers can make students tense, and they might become more worried about their grade and less worried about learning the material and challenging themselves. Participation and attendance, however, have a positive effect on students. Overall, they motivate students to at least come to class and take part in the engagement measuring process.

The results from the clicker surveys reveal that intrinsic motivation is still needed for students to pay attention in class. While graded quizzes will motivate students to physically come to the lecture, there is no guarantee that the use of clicker quizzes will help them pay attention. Instead, the quizzes based on academic content can be leveraged for professors to see how quickly and easily students are grasping new material, and for students to measure how well they are paying attention to the lecture.

5.2   Recommendations

Based on this study alone, it is recommended to use a combination of engagement measurement techniques, specially a combination of multiple choice based on academic content as well as free form feedback. A recommendation to improve ease of reading and analyzing free form data quickly would be to provide some way to aggregate free form data. This could be done by word frequency or highlighting only a couple of the most in-depth and insightful feedback submissions by students. It is also recommended not to grade the multiple choice based on academic content, but rather, just award points for participation.

Moving forward, this study can be elaborated to discover issues and roadblocks as to why professors are not adapting the clicker technology. While 68 professors at Northeastern are registered to use clickers, only 16 have ever logged in and only 8 responded to the survey and use the clickers regularly in their classes. Perhaps there is difficulty and effort involved on the professors' part for setting up such engagement tools. For them, it may be that they do not see the return on investment of time to set up such tools.

Recommendations for conducting the video experiment again would be to include a matrix of video segments that vary in quality and academic content level. While these attributes were combined in the current study, it was interesting to see that a fair amount of the students that participated reported the 'easy' academic content segment of the video as most engaging. This alludes to presentation and academic rigor as separate variables that correlate to engagement. Another recommendation to improve the current research study would be to rephrase the question on the clicker survey for professors regarding what question format they used for their clicker quizzes. One reported to not understand the question. As Google Forms saves the email information for participants of a survey, it would be advised to follow up with the professors individually and do more in-depth interviews. The last recommendation for the research study implementation would be to gather more data but administering the experiment and surveys to more students. This will improve the accuracy of the results. While simple random sampling was used in this iteration of the study, stratified random sampling would help the sample be more representative of the Northeastern student population in terms of distribution of majors and distribution of majors that use online lecture tools already.

Future modification that could be implemented in the video experiment that were not already would be to test the feedback measurement with time intervals as the variable. While only

the surveys were used to gather data for testing the hypothesis on the significant of the frequency of engagement measurements, the data was not very strong since students tend to only have a professor for one semester. Hence, there is no baseline to compare how frequency of engagement measurement improved or affected professors' ability to pinpoint. Another video experiment with the existing set up can be done where engagement measurement is taken after each segment as the control group, and in the variable group engagement measurement is taken only at the end of the video. Comparisons of the engagement feedback answers could reveal how frequency affects both student responses as well as how those responses are received and what they communicate to educators.

As the use of online tools is growing, research on engagement techniques will be more and more pertinent as the education format evolves in society. While this research study tested and accepted that feedback format and frequency of engagement measurements is significant for measuring engagements and pinpointing where improvements can be made, respectively, this research study only covered the surface. More in-depth research focusing on the the user experience for engagement tool setup for professors will help in uncovering and testing what data is the most effective in measuring engagement accurately and providing insight to professors.

References

Glassman, Juho Kim, Andrés Monroy-Hernández, and Meredith Ringel Morris. 2015. Mudslide: A Spatially Anchored Census of Student Confusion for Online Lecture Videos. In*Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15). ACM, New York, NY, USA, 1555-1564. DOI=http://dx.doi.org/10.1145/2702123.2702304

Grob, Sebastian Voigt, Thomas Janda, and Christoph Meinel. (2010). Technology based motivation of students to collaborate by digital annotations during real lecture and learning sessions. In *Proceedings of the 38th annual ACM SIGUCCS fall conference: navigation and discovery* (SIGUCCS '10). ACM, New York, NY, USA, 61-64. DOI=http://dx.doi.org/10.1145/1878335.1878351

Iqbal, Shamsi T., Piotr D. Adamczyk, Xianjun Same Zheng, and Brian P. Bailey. "Towards an Index of Opportunity: Understanding Changes in Mental Workload during Task Execution." *CHI '05 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems Pages 311-320* (2005): n. pag. *ACM Digital Library*. Web. 11 Apr. 2016.

Kibble, J. (2007). Use of unsupervised online quizzes as formative assessment in a medical physiology course: Effects of incentives on student participation and performance. *AJP: Advances in Physiology Education, 31*(3), 253-260. doi:10.1152/advan.00027.2007

Kulesza, A. E., Clawson, M. E., & Ridgway, J. S.. (2014). Student Success Indicators Associated With Clicker-Administered Quizzes in an Honors Introductory Biology Course.*Journal of College Science Teaching*, *43*(4), 73–79. Retrieved from http://www.jstor.org/stable/43632017

Strasser, Astrid Weiss, Roland Buchner, and Manfred Tscheligi. 2013. Alert in the cleanroom: testing alerting modalities for a task guiding interface. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '13). ACM, New York, NY, USA, 661-666. DOI=http://dx.doi.org/10.1145/2468356.2468473

6   Appendices

Appendix A
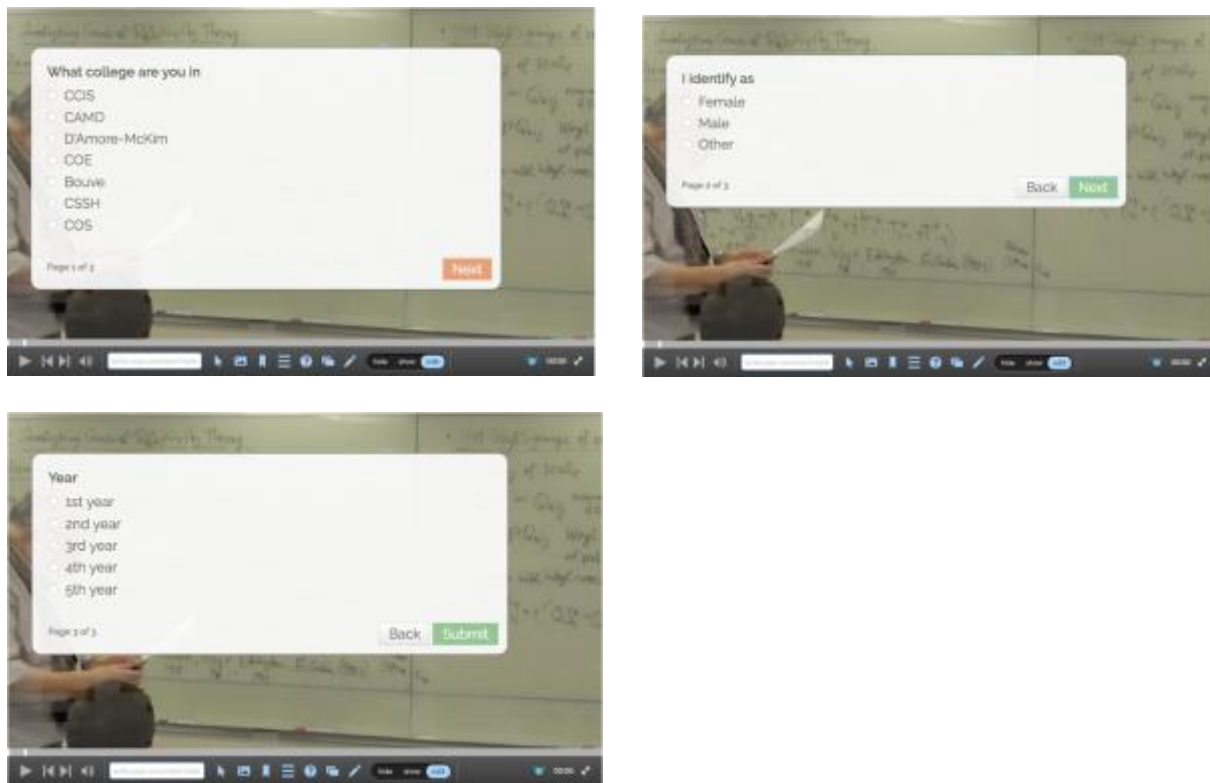
Figure 15: Example of pop-up module used in the Video Experiment. Questions were required to be answered in order to proceed in the video lecture. Such pop-engagement measurement interruptions were included at the beginning, after each segment, and at the end.

Appendix B

Table 8: Raw Data Optional Free Form Answers to What Made a Video Segment Engaging

User ID for those who elected to input their own answer	Which video was the most engaging?	Inputted Answers for 'What made it engaging?'
6bdcb8f9-f793-4b25-9832-fd612a5b8b8a	medium	Humor! It felt like it was directed towards a teenage audience, too.
f9016ba3-fcee-4529-9815-b35dcc64574d15	medium	The use of multimedia to convey a clear message and the clearness/briefness of the video
b1cc7fd8-15f6-4161-a530-e17bef5066e1	medium	Clear audio, subject matter was interesting and presented in a way meant to appeal to people who know nothing about organic chemistry.
fbe47183-7eb9-4bda-ad62-2ac35cd44bde	medium	Because it was the most engaging video and I felt like I was the most invested in the lecture.

Appendix C

Table 9: Raw Data Preferred Feedback Form and Free Form Answers for the Reasoning

preferred feedback form	Why?
Free form feedback text box	I usually prefer to write out my thoughts.
mc question about how I felt	It was easiest to answer because it was more focused on how I was feeling rather than the content of the video
mc question on lecture content	it prompted me to self-reflect on whether the lecture was helpful or confusing, causing me to think about what i just experienced and then quantify it in a question, remembering the material even more
Free form feedback textbox	I could elaborate on my thoughts
Free form feedback text box	I was able to give more information about how I felt and responded to the lecture. I was also able to explain why I could or could not answer the first MC question correctly.
mc question on lecture content	I prefer the MCQ format and felt that questions about the actual content made me think more about what I had just watched.
Free form feedback text box	it allows me to give you a more descriptive answer. no constraints.
Free form feedback text box	i like to be able to ask questions, tell issues etc
MC question on lecture content	I could see if i learned the material or not
Free form feedback text box	I like being able to write down whatever I want
Free form feedback text box	I could explain my answers to the other two questions and be more thorough about how I felt compared to just a MC question
Free form feedback text box	It felt less stressful than a MC question
Free form feedback text box	It was nice to be able to write down whatever
MC question on lecture content	It was good for assessing how well I had understood/internalized the material being taught
MC question on lecture content	it was quicker to fill out
MC question on lecture content	It was nice to tell if I learned or not

Free form feedback text box	I could address problems with the video itself. like audio problems
Free form feedback text box	I was able to provide my opinions rather than just addressing if I watched it or not
MC question on lecture content	MC on the material made me reflect on if I actually learned or not
MC question about how I felt	It was a quick way to tell if I understood the material
Free form feedback text box	The first form shows that the person was watching the video. The second form allows me to express my opinion on the video.
MC question on lecture content	addressed lecture best
Free form feedback text box	Because I like to be able to put down whatever I want
mc question on lecture content	because it measured if i know the material or not
mc question on lecture content	Because it measured if I actually understood what was happening or being taught in the videos
Free for feedback text box	freeform text boxes prompt people to think about their responses, which tend to be more insightful than checking off a question. Also the language could be more specific than just "feedback
mc question about how I felt	i'm not quite sure why....?
Free for feedback text box	I could put down whatever I want
Free for feedback text box	Easier to answer, don't need to think about it
mc question on lecture content	I feel that it is the most effective way to see if I learned something
mc question on lecture content	Free-form feedback is challenging to provide unless it's material that the participant cares/knows a lot about. For providing basic yes/no thumbs up/thumbs down a multiple choice question is easier.
mc question on lecture content	quick way to guage understanding
Free for feedback text box	let me express my opinions
Free for feedback text box	it made me have an opinion on the material rather than just focus on answering a question
Free for feedback text box	more free form

Free for feedback text box	Somewhat objective method of gauging level of understanding of the material
MC question about how I felt	quick and easy objective measure
mc question on lecture content	I felt that the multiple choice provided all the options I needed for how i would have described the lecture or how I felt.
mc question on lecture content	easier to explain
mc question on lecture content	easier to complete
Free for feedback text box	its nice not to be constrained

Appendix D

Table 10:Raw Free Form feedback Data for 'Easy' Lecture Segment

Entry	UserID	Easy Lecture Free Form Feedback
1	0e6eb06e-1c2b-4b79-b638-c8abb45a025f	that was so boring
2	495c013d-7c99-427e-8149-5c343ab4b0e6	lol. too slow. inaccurate grammar. weird adjectives like 'pretty, cute, long' in front of body parts that are subjective. unclear if you don't already know what hair, legs, ear, etc. are. weird music
3	841c0b60-ec69-474e-8adb-edb150ba3652	too slow of a speed, loud, unnecessary repetition
4	8d3c5469-9460-4db0-97b7-4b77a067a55f	That was annoying to watch and the music was weird lol but If I was a child or someone learning english It would probably be pretty helpful. Although the cartoon kid kind of creeped me out
5	ad26ec64-ece8-4c2e-b719-d784d04eaefe	It was very boring because it was very slow and the professor paused for long periods of time. There was also no information about each body part. A one page labeled diagram that we could learn in 15 seconds would be more helpful than this lecture. I also already knew all the material so that also contributed to its boringness.
6	b1cc7fd8-15f6-4161-a530-e17bef5066e1	I found it a little strange. I definitely tuned out at the beginning as I felt I knew the information but paid more attention when I realized the narrator was adding words etc.
7	b84a7b14-4d0c-4b8f-9919-da1ccfdf3433	too repititve
8	0774c3cd-e7ee-44b6-93e3-07399a12248d	overall it was a good lecture but i was bored
9	355adf41-1904-4346-b241-f96edbc3308e	The material wasn't that engaging. I already knew a lot of this
10	5d000e39-6fa7-4233-9932-bd826c793e64	it was a good video but i already knew the topic pretty well. this is meant for a younger audience.
11	6bdcb8f9-f793-4b25-9832-fd612a5b8b8a	i zoned out after the first couple of seconds

12	7cf3a587-a24b-440a-ba00-f9650c0b5b16	good presentation but boring material
13	7eddfb84-28db-437e-96c8-1c542dece001	was for small kiddies and was cute
14	95fc51f9-4601-41c5-bb4f-ec6d9a587f3a	Very clear but the background music and flashing letters could be distracting at times
15	f9016ba3-fcee-4529-9815-b35dcc64574d	Interesting graphics, easy to understand language
16	802ee8e5-c5c0-40b7-8708-63404be50942	aww adorable
17	9aa48080-6a41-4b7d-83ad-1b9a01a32a71	cute!
18	bd5ce86d-55b7-41d7-ae0f-e4d4cc02695e	this is made for younger children
19	c39bbf96-b770-47bd-bdb8-97b524ebb0c4	It was informative but seemed informal
20	db80683b-f5c7-4fda-b051-6cf64cd5685f	it was nice but repititive
21	e9a24ea7-3bef-4b5a-8d4f-f491f388fa57	The lecture was quite engaging and colorful, but a bit repetitive in presentation and tone. Also, the material was rather basic, but I can understand what its applications would be. Overall, it was an okay lecture.
22	2e12e6b7-bc50-4737-ac7c-9ae7dcfd0b7a	It was fun and cute at the beginning but I was disengaged beceause it got repititive after a while. Zoned out after a couple of seconds
23	495c013d-7c99-427e-8149-5c343ab4b0e6	cute and fun but lost interest pretty fast
24	69f56726-7a7c-4205-8b39-8805eaf797cb	that was a long 3 minutes
25	92607354-4a48-4679-8e9f-18321f7a2ce7	this is meant for children, repititive material
26	b1cc7fd8-15f6-4161-a530-e17bef5066e	stopped paying attention after about 30 seconds in. cute but boring
27	faabf165-9336-4f8d-918c-f08bbfcabc6f	very long, repetitive, boring, lost interest quickly
28	ea4a2de5-ee00-452f-a0c8-54096e2d25af	I tuned out for a lot of this. very boring.
29	37347870-6d16-4bfb-a0c3-1f94bc4d9584	this is meant for chilren
30	a2633bdc-7474-4867-96fa-924dd31e2fda	Good for ESL students. Funky music.

31	1e161df1-d68c-4141-bdf4-f9c7c97b49f7	This is either for very small children or children learning English as a second language. I did not personally find it interesting.
32	b1cc7fd8-15f6-4161-a530-e17bef5066e1	It was cute and fun to watch
33	bdb3069e-4bb8-45f6-a7fc-d4d6bf4775b9	cute video!
34	fbe47183-7eb9-4bda-ad62-2ac35cd44bde	I thought that this would be good for a child learning body parts and basic anatomy.
35	0a12b661-9f15-4b85-984b-31f240aabf53	This was a video meant for children. Lost interest into a couple of seconds into the video
36	0f50e549-da96-4b90-b626-eff80791af89	nice refresher on body parts
37	2acfc7b7-0092-4d39-98ac-7c441740666b	Engaging in terms of visuals but the content was very basic.
38	47750383-7f64-42c8-942a-2f780d316bda	This was boring material but the video was well done.
39	495c013d-7c99-427e-8149-5c343ab4b0e6	Engaging graphically, but the information was not too comprehensive. Very simplistic.
40	ad26ec64-ece8-4c2e-b719-d784d04eaefe	I liked the third video the most. I felt it was the most engaging and provided great visual examples
41	2dde3a12-16fa-4ef9-8bab-acdfc6a83996	was this video for 5 year olds

Appendix E

Table 11: Raw Freeform Feedback Data for 'Medium' Lecture Segment

Entry	UserID	Medium Lecture Free Form Feedback
1	0e6eb06e-1c2b-4b79-b638-c8abb45a025f	much more engaging than the first
2	495c013d-7c99-427e-8149-5c343ab4b0e6	It was engaging because of his tone of voice and also because of the animations
3	841c0b60-ec69-474e-8adb-edb150ba3652	the animations were nice
4	8d3c5469-9460-4db0-97b7-4b77a067a55f	nice visuals
5	ad26ec64-ece8-4c2e-b719-d784d04eaefe	much better than the first segment
6	b1cc7fd8-15f6-4161-a530-e17bef5066e1	it was fun and engaging
7	b84a7b14-4d0c-4b8f-9919-da1ccfdf3433	better. talks directly to you, fast-paced but easy to understand. breaks up the education with fun tidbits and illustrations to keep your attention.
8	0774c3cd-e7ee-44b6-93e3-07399a12248d	fun and informative
9	355adf41-1904-4346-b241-f96edbc3308e	great video. funny and informative
10	5d000e39-6fa7-4233-9932-bd826c793e64	that was interesting
11	6bdcb8f9-f793-4b25-9832-fd612a5b8b8a	better than the last video!
12	7cf3a587-a24b-440a-ba00-f9650c0b5b16	this video was also entertianing like that last one but i felt the content was better
13	7eddfb84-28db-437e-96c8-1c542dece001	Entertaining way of providing information in a simple manner!
14	95fc51f9-4601-41c5-bb4f-ec6d9a587f3a	I LOVE THIS GUY. His crash courses are the best! He is informative and clear without underestimating or overestimating his audience.
15	f9016ba3-fcee-4529-9815-b35dcc64574d	interesting lecture
16	802ee8e5-c5c0-40b7-8708-63404be50942	Interesting, interactive, and informative

17	9aa48080-6a41-4b7d-83ad-1b9a01a32a71	entertaining and effective
18	bd5ce86d-55b7-41d7-ae0f-e4d4cc02695e	i liked the animation
19	c39bbf96-b770-47bd-bdb8-97b524ebb0c4	the guy is funny and was engaging
20	db80683b-f5c7-4fda-b051-6cf64cd5685f	Entertaining and effective way to present educational material
21	e9a24ea7-3bef-4b5a-8d4f-f491f388fa57	effective fun and colorful. nice
22	2e12e6b7-bc50-4737-ac7c-9ae7dcfd0b7a	interesting
23	495c013d-7c99-427e-8149-5c343ab4b0e6	more engaging that the first
24	69f56726-7a7c-4205-8b39-8805eaf797cb	the animations and images made it very engaging
25	92607354-4a48-4679-8e9f-18321f7a2ce7	the instructor was funny and went at a good pace. better than the pace of the first video
26	b1cc7fd8-15f6-4161-a530-e17bef5066e	fun, informative, and engaging
27	faabf165-9336-4f8d-918c-f08bbfcabc6f	interesting funny and informative video
28	ea4a2de5-ee00-452f-a0c8-54096e2d25af	he is funny and that helped me pay attention
29	37347870-6d16-4bfb-a0c3-1f94bc4d9584	Although I am not very interested in the material that was covered I think that the lecturer was very engaging.
30	a2633bdc-7474-4867-96fa-924dd31e2fda	Neat and engaging lecture because of pace and animations
31	1e161df1-d68c-4141-bdf4-f9c7c97b49f7	Would have been curious to see the rest of it. Found the presenter to be slightly annoying, but his presentation of the material was good enough that I didn't mind continuing to watch.
32	b1cc7fd8-15f6-4161-a530-e17bef5066e1	Funny and intersting to watch!
33	bdb3069e-4bb8-45f6-a7fc-d4d6bf4775b9	I liked the animations and thought the speaker was lively
34	fbe47183-7eb9-4bda-ad62-2ac35cd44bde	Entertaining way to present material

35	0a12b661-9f15-4b85-984b-31f240aabf53	informational and interesting
36	0f50e549-da96-4b90-b626-eff80791af89	the guys funny and informative
37	2acfc7b7-0092-4d39-98ac-7c441740666b	the guy talking was a good presenter - kept me interested - wasn't boring to watch - don't know anything about chem but he explains it well
38	47750383-7f64-42c8-942a-2f780d316bda	I already knew this stuff but i thought the video was engaging
39	495c013d-7c99-427e-8149-5c343ab4b0e6	Very comprehensive and well thought out. Engaging and interesting.
40	ad26ec64-ece8-4c2e-b719-d784d04eaefe	I thought this was very engaging
41	2dde3a12-16fa-4ef9-8bab-acdfc6a83996	guy makes an effort to keep you interested

Appendix F

Table 12: Raw Freeform Feedback Data for 'Hard' Lecture Segment

Entry	UserID	Hard Lecture Free Form Feedback
1	0e6eb06e-1c2b-4b79-b638-c8abb45a025f	i couldn't hear much
2	495c013d-7c99-427e-8149-5c343ab4b0e6	not sure if i hear any of that too be honest
3	841c0b60-ec69-474e-8adb-edb150ba3652	the writiing wasn't legible
4	8d3c5469-9460-4db0-97b7-4b77a067a55f	i can't understand what he's saying
5	ad26ec64-ece8-4c2e-b719-d784d04eaefe	he is not speaking at the camera so it hard to understand what is going on
6	b1cc7fd8-15f6-4161-a530-e17bef5066e1	Not sure what that was about to be honest. I think it was physics or calculus
7	b84a7b14-4d0c-4b8f-9919-da1ccfdf3433	i just guessed. i can't understand what he's saying due to poor microphones and a thick accent. he's also not speaking directly to the camera, aka me. the coughing of a person is distracting because it blocks out all other noise.
8	0774c3cd-e7ee-44b6-93e3-07399a12248d	coudnt hear very well
9	355adf41-1904-4346-b241-f96edbc3308e	It was very difficult to hear what was being said by the professor. I don't think I heard anything at all honestly.
10	5d000e39-6fa7-4233-9932-bd826c793e64	i was bored
11	6bdcb8f9-f793-4b25-9832-fd612a5b8b8a	his was the longest 3 minutes of my life. I probably picked up 2% of what he just said. I also cringe at science in general so that didn't help at all
12	7cf3a587-a24b-440a-ba00-f9650c0b5b16	the professor is smart but presentation could be better
13	7eddfb84-28db-437e-96c8-1c542dece001	was really boring (it was either physics or calc I couldn't tell)
14	95fc51f9-4601-41c5-bb4f-ec6d9a587f3a	Very unclear, hard to understand the professor.

15	f9016ba3-fcee-4529-9815-b35dcc64574d	was hard to hear anything
16	802ee8e5-c5c0-40b7-8708-63404be50942	The professor is very knowledgeable
17	9aa48080-6a41-4b7d-83ad-1b9a01a32a71	Very difficult to hear
18	bd5ce86d-55b7-41d7-ae0f-e4d4cc02695e	i couldnt hear or see well
19	c39bbf96-b770-47bd-bdb8-97b524ebb0c4	it was really hard to hear and see what was written on the board
20	db80683b-f5c7-4fda-b051-6cf64cd5685f	i didnt pick up much of what was said
21	e9a24ea7-3bef-4b5a-8d4f-f491f388fa57	i had my volume turned up all the way but still couldnt hear
22	2e12e6b7-bc50-4737-ac7c-9ae7dcfd0b7a	out of context and almost inaudible
23	495c013d-7c99-427e-8149-5c343ab4b0e6	not sure if i picked up anything that was said. Hard to hear and read the board
24	69f56726-7a7c-4205-8b39-8805eaf797cb	I wish he had a microphone or better handwriting
25	92607354-4a48-4679-8e9f-18321f7a2ce7	I couldn't hear the professor and his writing was not legible so I didn't learn anything or process anything he was saying.
26	b1cc7fd8-15f6-4161-a530-e17bef5066e	I would've given the professor a microphone as a the videographer.
27	faabf165-9336-4f8d-918c-f08bbfcabc6f	couldnt hear much
28	ea4a2de5-ee00-452f-a0c8-54096e2d25af	i couldn't hear the professor very well
29	37347870-6d16-4bfb-a0c3-1f94bc4d9584	Material was dense
30	a2633bdc-7474-4867-96fa-924dd31e2fda	Difficult to pierce accent. Atrocious handwriting.
31	1e161df1-d68c-4141-bdf4-f9c7c97b49f7	It was impossible to hear and started halfway through a lecture on general relativity, both things that made it hard to follow.
32	b1cc7fd8-15f6-4161-a530-e17bef5066e1	very inaudible. I couldn't even tell what the lecture was on
33	bdb3069e-4bb8-45f6-a7fc-d4d6bf4775b9	this material was too dense for me and i found it hard to follow along

34	fbe47183-7eb9-4bda-ad62-2ac35cd44bde	I didn't really grasp anything that was said or written on the board so I just guess on the multiple choice
35	0a12b661-9f15-4b85-984b-31f240aabf53	It was hard to hear and understand, especially since the video started in the middle of a lecture and it seemed like a lot was already covered about the topic.
36	0f50e549-da96-4b90-b626-eff80791af89	I couldnt see what was written on the board very well and the volume was too low so it was hard to follow
37	2acfc7b7-0092-4d39-98ac-7c441740666b	I didn't really follow much of what was said to be honest
38	47750383-7f64-42c8-942a-2f780d316bda	have no clue what he said - couldn't understand / hear what he was saying
39	495c013d-7c99-427e-8149-5c343ab4b0e6	Difficult to understand. While it seems like the information was comprehensive, was very dull and easy to tune out.
40	ad26ec64-ece8-4c2e-b719-d784d04eaefe	I didn't really like the second video. It was a bit hard to understand, also it wasn't really engaging.
41	2dde3a12-16fa-4ef9-8bab-acdfc6a83996	can't hear the lecturer, confusing

Appendix G

Table 13: Raw Data for Responses on Nonverbal Disengagement Cues

Timestamp	What college are you part of?	What Class(es) have you used the clicker in?	How can you tell if students are zoning out in class? What are some nonverbal cues that indicate a student is not paying attention in lecture?
4/7/2016 10:10:08	Bouve	CDM 1 through 4, Biopharm/Kinetics	not looking at me or typing but just looking at their computer screens, sleeping, talking to each other
4/7/2016 10:13:58	Bouve	NRSG 3302, 4610	Eyes are closed
4/7/2016 10:22:54	COE	ENCP 6000 Career Management for Engineers	Looking, at cell phones, sleeping, doing other work
4/7/2016 10:52:20	CCIS	CS2800	Students are asleep; students are talking with other students; students are using their laptops.
4/7/2016 13:30:13	Bouve	Physical Diagnosis, Medicine	nodding off, going to the bathroom more, multiple same questions
4/8/2016 14:25:19	Bouve	Exercise Physiology	Steering away from powerpoint slides.
4/10/2016 13:03:05	CAMD	Rock Music - MUSC1111	Sleeping in class
4/11/2016 7:05:31	Bouve	UG	Not looking at me, focusing on their laptops.

Appendix H

Table 14: Raw Data for Responses on Lecture Experience Changes With Clicker Use Adoption

Timestamp	What college are you part of?	What Class(es) have you used the clicker in?	How would you compare your lecturing experience before and after the use of clicker quizzes? It what ways has it improved?
4/7/2016 10:10:08	Bouve	CDM 1 through 4, Biopharm/Kinetics	clickers is an effective formative strategy that allows me to assess baseline knowledge and assess whether students are able to apply new concepts. It is also an effective strategy to challenge students with more than typical scenarios and ask them to provide rationale for specific answers they choose to get them to engage with the material in a greater depth
4/7/2016 10:13:58	Bouve	NRSG 3302, 4610	More attentive students, more engaged; increased satisfaction as stated in TRACE evaluations
4/7/2016 10:22:54	COE	ENCP 6000 Career Management for Engineers	Its just another technique for class engagement, if I did not have a large enrollment class I probably would not sue them
4/7/2016 10:52:20	CCIS	CS2800	It has not improved.
4/7/2016 13:30:13	Bouve	Physical Diagnosis, Medicine	improved.
4/8/2016 14:25:19	Bouve	Exercise Physiology	More engaging, real-time feedback, and improved student performance.
4/10/2016 13:03:05	CAMD	Rock Music - MUSC1111	Attendance is much better especially at the end of the semester
4/11/2016 7:05:31	Bouve	UG	Keeps students engaged. Able to show example exam-type questions.

Appendix I

Table 15: Raw Data for Response on Students' Sentiments Toward Clicker Use Adoption

Timestamp	What college are you part of?	What Class(es) have you used the clicker in?	How have student felt about the use of clickers in your class? What has been the general feedback
4/7/2016 10:10:08	Bouve	CDM 1 through 4, Biopharm/Kinetics	they like it
4/7/2016 10:13:58	Bouve	NRSG 3302, 4610	They really liked them until they started getting charged a licensing fee ....just one more additional fee that creates dissatisfaction with the already high tuition
4/7/2016 10:22:54	COE	ENCP 6000 Career Management for Engineers	As it is ties to their attendance they don't like it, mostly that they have to pay for it.
4/7/2016 10:52:20	CCIS	CS2800	I haven't polled them about this, but they find them somewhat annoying and resent the expense.
4/7/2016 13:30:13	Bouve	Physical Diagnosis, Medicine	they love it
4/8/2016 14:25:19	Bouve	Exercise Physiology	Very helpful, appreciative, self-feedback.
4/10/2016 13:03:05	CAMD	Rock Music - MUSC1111	Overall, very positive. However, a small number found them challenging to use
4/11/2016 7:05:31	Bouve	UG	Positive

Appendix J

Table 16: Raw Data for Responses on Most Effective Clicker Questions

Timestamp	What college are you part of?	What Class(es) have you used the clicker in?	What type of clicker questions have you found to be the most effective?
4/7/2016 10:10:08	Bouve	CDM 1 through 4, Biopharm/Kinetics	not sure I understand your question
4/7/2016 10:13:58	Bouve	NRSG 3302, 4610	Multiple choice
4/7/2016 10:22:54	COE	ENCP 6000 Career Management for Engineers	we only use MC/TF
4/7/2016 10:52:20	CCIS	CS2800	The ones with specific examples of material covered in class.
4/7/2016 13:30:13	Bouve	Physical Diagnosis, Medicine	multiple choice
4/8/2016 14:25:19	Bouve	Exercise Physiology	multiple choices
4/10/2016 13:03:05	CAMD	Rock Music - MUSC1111	Multiple choice regarding course content and general interest polls
4/11/2016 7:05:31	Bouve	UG	Multiple choice

Appendix K

Table 17: Raw Data for Responses on Least Effective Clicker Questions

| Timestamp	What college are you part of?	What Class(es) have you used the clicker in?	What type of clicker questions have you found to be the least effective?
4/7/2016 10:10:08	Bouve	CDM 1 through 4, Biopharm/Kinetics	not sure I understand your question
4/7/2016 10:13:58	Bouve	NRSG 3302, 4610	None
4/7/2016 10:22:54	COE	ENCP 6000 Career Management for Engineers	NA
4/7/2016 10:52:20	CCIS	CS2800	Generic questions
4/7/2016 13:30:13	Bouve	Physical Diagnosis, Medicine	t/f
4/8/2016 14:25:19	Bouve	Exercise Physiology	short answer and essay questions.
4/10/2016 13:03:05	CAMD	Rock Music - MUSC1111	---
4/11/2016 7:05:31	Bouve	UG	n/a

Appendix L
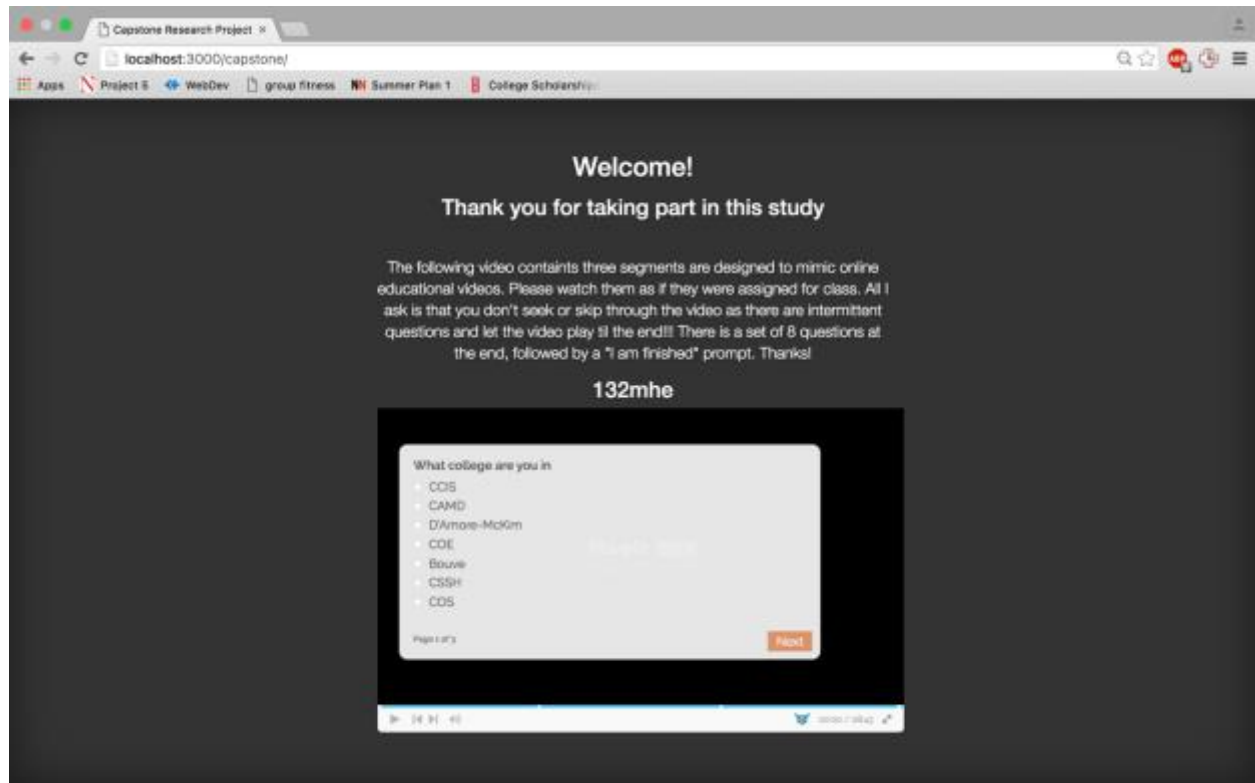
Figure 16: Webpage Used for Conducting Video Experiment

Appendix M

```javascript
(function () {
    angular
        .module ("CapstoneApp")
        .controller ("HapYakController", HapYakController)


    function HapYakController ($sce) {

        var vm = this;
        var projectId = null;
        var project_title = null;
        //the videos
        var videos = [
            33136, //123meh
            33121, //231ehm
            33122, //213emh
            33137, //132mhe
            33138, //312hme
            33139  //321hem
        ];
        // the respective titles for each projectId
        var title = {
            33136: '123meh',
            33121: '231ehm',
            33122: '213emh',
            33137: '132mhe',
            33138: '312hme',
            33139: '321hem'
        };

        vm.safeRandomHapYakUrl = function safeRandomHapYakUrl() {

            projectId = videos[Math.floor(Math.random() * videos.length)];

            return $sce.trustAsResourceUrl("//www.hapyak.com/embed?key=dfd98f9f3a3c427fa552&project="+projectId);

        }

        vm.videoTitle = function videoTitle() {

            if (projectId) {
                project_title = title[projectId];
            }

            return project_title;



        }
    }
})();
```

Figure 17: Angular.js Used for Random Sampling for Serving Video Experiment Content

Appendix M

Clicker_Survey_Students

QUESTIONS	RESPONSES 56

Section 1 of 2

Clicker Use Survey

A quick survey on use of clickers in Northeastern University. Your response is much appreciated!

What college are you part of

○ CAMD

○ D'Amore-McKim

○ CCIS

○ COE

○ Bouve

○ CSSH

○ COS

Have you had a class where you had to use a clicker?

○ No

After section 1   Continue to next section   ▾

Section 2 of 2   ˅ ˄   ⋮

just a couple more questions

Description (optional)

Were the clicker answers factored into your grade?

○ Yes

○ No

Check all that apply

☐ The clickers were mainly used to check into class- like a sign in sheet. For attendance points

☐ The clickers were used to quiz us on class material

When were the clicker quizzes administered? Check all that apply.

☐ beginning of class

☐ end of class

☐ in the middle of class

In order to be the most effective, clicker quizzes should be on material covered in class

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

In order to be the most effective, clicker quizzes should only be used for attendance/participation grading

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Clicker quizzes on class material helps me realize how well I understand the material

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Professors are more effective when they use clicker quizzes

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I felt that clicker quizzes helped me focus in class and prevent me from zoning out

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Clicker quizzes on class material should be graded

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Using clicker sign-ins for lecture attendance points is effective and motivates me to come to class

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I felt that clicker quizzes helped the professor understand what concepts students were struggling to learn

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

When should clicker quizzes be administered in a class? Check all

☐ At the beginning of class to review where we left off

☐ At the beginning of class for attendance

☐ 1-3 times during class

☐ more than three times during class

☐ At the end of class to summarize the lecture

☐ Not at all. I do not find them effective.

How often to do you zone out in a class?

○ Every 10 minutes

○ Every 15 minutes

○ only when I am bored

○ Rarely ever

Appendix N

Clicker_Survey_Professors

QUESTIONS   RESPONSES   8

NEU Clicker Use Survey

A quick survey on use of clickers in Northeastern University. Your response is much appreciated!

What college are you part of?

○ CAMD

○ D'Amore-McKim

○ CCIS

○ COE

○ Bouve

○ CSSH

○ COS

What Class(es) have you used the clicker in?

Short answer text

Clicker_Survey_Professors

QUESTIONS   RESPONSES   8

NEU Clicker Use Survey

A quick survey on use of clickers in Northeastern University. Your response is much appreciated!

What college are you part of?

CAMD

D'Amore-McKim

CCIS

COE

Bouve

CSSH

COS

What Class(es) have you used the clicker in?

Short answer text

| Strongly Disagree | ○ | ○ | ○ | ○ | ○ | Strongly Agree |

Clicker quizzes on class material helps me realize how well my students understand the material

| | 1 | 2 | 3 | 4 | 5 | |
| Strongly Disagree | ○ | ○ | ○ | ○ | ○ | Strongly Agree |

Using Clicker Quizzes has made me a more effective lecturer

| | 1 | 2 | 3 | 4 | 5 | |
| Strongly Disagree | ○ | ○ | ○ | ○ | ○ | Strongly Agree |

I feel that clicker quizzes help my students focus in class and prevent them from zoning out

| | 1 | 2 | 3 | 4 | 5 | |
| Strongly Disagree | ○ | ○ | ○ | ○ | ○ | Strongly Agree |

Clicker quizzes on class material should be graded

| | 1 | 2 | 3 | 4 | 5 | |
| Strongly Disagree | ○ | ○ | ○ | ○ | ○ | Strongly Agree |

Using clicker sign-ins for lecture attendance points is effective and motivates students to come to class

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I feel that clicker quizzes help me understand what concepts students were struggling to learn

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

In your opinion, when should clicker quizzes be administered in a class? Check all that apply

☐ At the beginning of class to review where we left off

☐ At the beginning of class for attendance

☐ 1-3 times during class

☐ more than three times during class

☐ At the end of class to summarize the lecture

☐ Not at all. I do not find them effective.

How can you tell if students are zoning out in class? What are some nonverbal queues that indicate a student is not paying attention in

Long answer text

How would you compare your lecturing experience before and after the
use of clicker quizzes? It what ways has it improved?

Long answer text

How have student felt about the use of clickers in your class? What has
been the general feedback

Long answer text

What type of clicker questions have you found to be the most

Short answer text

What type of clicker questions have you found to be the least

Short answer text