Fly Sci with Miss Ontai: An Interactive Science Web-series to Engage Middle School Students

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Introduction

Science education today is facing a troubling problem: schools are failing to engage students in science classes. In a survey of 15-year-old students in twenty-five countries about their interest in, trust in, and views of school science, and their future career hopes, there was a 0.92 negative correlation between their responses and United Nations comparative national Index of Human Development. This means that, shockingly, the more advanced and economically prosperous a country is, the less its young people are drawn to the study of science, and the less they are inclined to trust and value science (Turner and Peck 2010). In 2005, the Organization for Economic Co-operation and Development reviewed data that showed such daunting declines in the percentages of students studying science, technology, engineering and mathematics (STEM), they recommended that governments take action to make science and technology studies more attractive to students (Ainley and Ainley 2011).

Within the U.S., an even more disheartening trend occurs: students experience a significant drop of levels of engagement in science classes starting at the middle school level. In a 2007 study with students ages 9-14 in Albuquerque New Mexico, researchers found that over the course of three years, positive science attitudes dropped with age, especially between elementary and middle school, and they never recovered their previously more positive attitudes towards science over the course of the study (Sorge 2007). This significantly affects engagement, as Programme for International Student Assessment in 2004 as noted that engagement and attitude levels are interrelated (PISA 2004). Another ethnographic study in 2007 on urban Latino boys over the course of 2.5 years found that student engagement with science at this urban middle school was mostly described by the phrase “school is so boring” (Mora 2011). Further studies have also confirmed that student engagement with and interest in science tends to decline around middle school age (Willms, Parson, and Friesen 2009; Parsons and Taylor 2011; Vedder-Weiss and Fortus 2011). A lack of student engagement not only may decrease student achievement in science, but it has been linked to disrupting class, cutting class, and even dropping out (Bridgeland et. al. 2006; Mora 2011).

Part of this disengagement with science material can be linked to the current standards in America for teaching, with high-stakes testing prevailing across the nation. Within Texas, students are required to take standardized tests starting in 3rd grade and ending in high school. Teachers are expected to teach the TEKS, or Texas Essential Knowledge and Skills, to students by test time, as the TEKS are what they are tested on ("STAAR Resources"). STAAR test scores are used to determine funding for a school or a district, to determine if the school will be punished or completely shut down, or whether or not a student will be held back for another year ("Financial Exigency," "STAAR Resources"). These scores are extremely important, and it leads unfortunately to a test-driven curriculum in some cases. Teachers are pressed for time, with one US nationwide survey stating that 71% of districts reported cutting at least one subject in order to increase time spent on reading and math as a direct response to the high-stakes tested enacted under No Child Left Behind (Au 2011). When teachers were surveyed in two large school districts under high-stakes testing pressure, 68% reported that they spent a significant time on test preparation (Shepard and Dougherty 1991). Another nationwide survey found that the amounts of time allocated to test preparation were greater in high-stakes testing districts (Pedulla et. al. 2003). In order to save time on instruction to be able to devote more time to test preparation, teachers have turned to teacher-centered activities, such as lectures (Faulkner and Cook 2006). However, lecture-based activities have shown to promote disengagement among the youth. Students have been found to be more disengaged in traditional lecture-based activities

(Larson and Richards 1991). In Mora's ethnographic study of Latino urban middle schools, the children were found to be increasingly disenfranchised with traditional lecturing, and they pushed for more interesting activities that had more variety, allowed them to interact with their teachers rather than just sitting at their desks taking notes (2011). Additionally, a descriptive metanalysis of literature found that traditional lectures longer than 10-15 allowed for decreased student engagement as instruction droned on, as students' attention spans were not longer than that (Middendorf and Kalish 1996). Thus, traditional lectures driven by high-stakes testing to allow for more content to be crammed into less time, which has been a driving part of disengagement with science education at a middle school level.

A possible way to alleviate disengagement of middle school students could be in the use of technology in schools. In a survey of 59 high schools from 23 different states around the nation, 79% adolescents reported that projects and lessons involving technology engaged them to some extent (2014 NAIS Report on the High School S...). In a national survey of teachers, survey takers reported that 51% of their students are more motivated to learn by the incorporation of technology into their lessons (Unleashing the Future: Educators "spe...). One particular form of technology, interactive videos, may prove to be useful as a supplement or even a replacement for traditional lectures. In videos tested amongst first-level accounting courses in a university, researchers found that the video with design elements that included graphics/cartoons and sounds/music clips had the most learning benefits associated with them, indicating that a more "fun" learning environment yields a helpful tutoring effects for more students (Brecht 2012). Additionally, 138 students from a large university in the southwestern United States were subjected to treatments of either a traditional lecture or an interactive video, and interactive video was found to have positive effects on both learning outcome and learner satisfaction (Zhang et al.

2006). Thus, interactive videos show a promise of engaging students once again with their science materials.

Interactive videos may also be helpful in learning science by showing an alternative to the stereotypical scientist image. In a 1983 study where students were asked to draw a scientist, less than 1% of them drew a woman as a scientist, and a majority of them drew a man in a lab coat with glasses as a scientist (Chambers 1983). This stereotypical image of a man as a scientist is still present today. In a survey of citizens in more than 34 countries, 70% of surveys revealed implicit stereotypes associating science with males and language arts with females; countries that showed such an implicit bias also showed that boys in middle school were higher-achieving in science than girls were, the U.S. being one of these countries (Nosek et al. 2009). Furthermore, the National Science Institute reported that in 2010, more than half of the jobs in science or engineering fields were held by white men, leaving women and minority groups severely underrepresented in science (National Center for Science and Engin...). In several analyses of science TV shows shown to be popular amongst middle school-age children, women and minorities were found to have less screen time and represent fewer respected, adult scientist characters in the TV series as opposed to their white, male counterparts (Steinke and Long 1996; Long et al. 2001).

What my thesis proposes to do is to create a series of engaging, interactive videos with integrated worksheets that also include TEKS. Such a video will help in the context of high-stakes testing, as it allows for students to learn material quickly, while also conforming to state objectives and reigniting interest at a crucial time in adolescent formation. Additionally, I, an Asian-American woman, would act as the host of this show, which would allow for an alternative to the white, male scientist stereotype. In summary, my thesis project seeks to tackle the problem of middle school disengagement with science by providing them with engaging, interactive videos that will hopefully break the stereotypes of a typical scientist.

Literature Review

The use of educational video as a learning tool is not a novel practice. Beginning in WWII, film strips were shown to soldiers as a training tool. In the 1950s and 1960s, instructional television lectures became widely implemented within classrooms. Video has evolved from educational television designed to complement classrooms, to educational standards-based videos designed specifically to serve as supplemental tools (Cruse 2011). One widely used form of supplemental video are video podcasts, which have gained popularity with the formation and rise in popularity of Youtube in 2005-2006 and the dramatic increase in bandwidth available to the public 2006-2010. Video podcasts are widely implemented in online courses as well as supplemental materials to traditional classrooms (Kay 2012). Additionally, video podcasts are implemented in a popular form of teaching called flipped lesson plans, where video lectures and practice problems are watched outside of class, and active, group-based problem solving activities are done in the classroom (Bishop and Verleger 2013). Video technology has become widely used in classrooms, and it is also considered to be a highly valued means of teaching more effectively and creatively (Cruse 2011).

There are many benefits to using video technology within classrooms. Firstly, it caters to the current "Net Generation." Generational systems have been developed that generally classify generations as Matures (1900-1946), Boomers (1946-1964), Generation X (1965-1982), and Net Generation/Millennials (1982-present). The Net Generation is distinct from other generations in their characteristics and learning expectations, and they span the majority of students that are in middle schools, high school, and higher education today (Oblinger et al. 2005; Strauss and Howe 2000). The Net Generation demands a greater autonomy in everything that they do, particularly when it comes to freedom of choice and their environment (Tapscott 1998). Research has shown that with the supplemented use of video podcasts in classrooms, students seemed to enjoy the freedom to control when and where they learned, what they learned, their pace of learning (Kay 2012). Additionally, N-geners seem to value emotional and intellectual, inclusion of diversity, immediacy of knowledge, and curiosity, discovery, and exploration (Tapscott 1998). It has been argued that education today may require a paradigm shift to a more learner-centered model of instruction to appeal to N-geners, which includes visualizations, simulations, and case-analyses as effective methods of engaging students of today (Skiba and Barton 2006); all these values can be easily integrated into an interactive video.

Interactive video is defined as any video which the user has "more than the minimal 'on-off' control over what appears on the screen." This means that users are able to select or play a segment or individual frame, pause at a single frame, slow down or speed up a clip; all of these features are enabled on a digitized video (Kearney and Treagust 2001). Using interactive video as a learning tool is founded within the theory of constructivism. Constructivism views learning as forming abstract concepts in the mind in order to represent reality; learning occurs when a learner constructs their own unique, internal concepts to represent their own knowledge. Constructivism argues that active participation in learning activities motivates and engages students more than passive activities, and learners are thought to learn best when they interact with their environment themselves and control the pace of learning. Both autonomy over learning pace as well as motivation and engagement are afforded to the student in interactive video (Zhang et al. 2006).

In accordance with creating a learner-centered model to appeal to the generation of students today, videos are a beneficial tool because they appeal to the way that individual students may process learning. Cognitive information processing theory, which looks at the role of memory, states that individuals receive information, organise that group of information, connect it with previous knowledge, and then transfer and encode that memory into the memory store, and then recall from memory to apply knowledge to their learning environment. A major assumption of the theory is that learners have a limited attention span and that they are uniquely selective in what they will pay attention to. Thus, the theory supports the use of differentiated instruction in order to focus the individual learner's attention, support their encoding and retrieval, and provide meaningful, relevant practice of retrieval across the learning environment. Therefore, appealing to different learning styles through multiple modes such as sight, movement, or sound can create a richer instructional tool that allows for knowledge to disseminate to a more broader audience (Reiser and Dempsey 2007; Wang et al. 2001; Arthurs 2007; Anderson 2016; Zhang et al. 2006; Cruse 2011). Differentiation in classrooms, by appealing to a wider variety of students, has also shown to increase learner motivation (Davies et al. 2013; Larkin and Budny 2005).

From these theoretical frameworks, it could follow that the use of video within classrooms should increase learner achievement, which research does indeed show. A survey done in 2004 by the Corporation for Public Broadcasting found that "children's viewing of educational television has been shown to support significant and lasting learning gains" and that "a positive relationship has been found between childhood viewing of educational television and cognitive performance at both preschooler and college levels" (Saltrick et al. 2004). A study on the academic impact of students viewing Bill Nye the Science Guy both at home and at school showed that "students who watched the program were able to provide more complete and complex explanations of scientific concepts after viewing the show" and that "the gaps in knowledge base between boys and girls and between minority and majority students were smaller and closer to parity after viewing the program" (Cruse 2011; Rockman and Others 1996). A study in which eighth grade students viewed instructional television over the course of six weeks found that "students in the classes which included the television programming outperformed the control groups in test scores, writing assignments, in variety and creativity of problem-solving skills, and in their engagement in class discussion" (Cruse 2011; Barnes 1997). Various other studies have been performed that also show that students learn efficiently through instructional television (Schramm 1962)

While video technology in and of itself may be engaging and lend itself to increased engagement and learning, different elements of the video are important as well. Some of the different pedagogical elements that I wish to include in my web-series are humor, music, and authentic tasks. Humor has been proven to have positive psychological effects on students. It has been shown to reduce stress, decrease anxiety, enhance self-esteem, and increase self motivation. Humor can create a positive environment conducive to learning, and can serve to bridge a gap between teacher and student by creating a shared understanding and common psychological bond. Bridging such a gap is important, as the connection established between the instructor and the student had been found to be a key part of effective teaching (Garner 2006; Glaser and Bingham 2012). Humor can create a shared experience which allows the student to feel a connection with the teacher and other classmates, acting as an "educational lubricant" to make learning more "engaging, enjoyable, and memorable" (Shatz and Coil 2008).

Furthermore, humor has been shown to positively impact learning and teaching. Students indicate that humor increases their interest in learning, and researchers have shown that students with a teacher that has a "strong orientation to humor" tend to learn more. Additionally, humor has been shown to stimulate creativity; a study found that humorous atmosphere in the classroom impacted student scores on divergent thinking exercises in a positive manner (Garner 2006). Specifically in online, distance learning classes, using e-lectures, videos, and podcasts, humor encourages a higher rate of participation and attendance, as well as a higher amount of engagement (Garner 2006; Shatz and LoSchiavo 2006).

Music has also been found to be an effective pedagogy to engage students. Within science, it has been reported that many students may feel out of place in the classroom; however, music has been shown to reduce stress and make students feel more comfortable in a science classroom (Osborne et al. 2003; Levine and Edelstein 2009; Crowther 2012). Music engages a wide variety of cultures, and also reflects popular culture, which may also allow students to feel more connected and comfortable in a classroom (Hall 2010; Hall 2008). Music can also be a tool to help memorization. It allows for mnemonic encoding and organization, which has been shown to increase memorability, and it also evokes strong emotions, which can enhance some aspects of memory (Crowther 2012; Bower and Bolton 1969; Bellezza 1981) Additionally, a doctoral dissertation suggested that revisiting ideas in a different style of delivery, such as song, could allow better recall and understanding amongst middle school classes as opposed to just re-lecturing (Governor 2011).

While there is a general lack of research surrounding the efficacy of using music to teach in classrooms, several studies have been conducted on the subject. A study of high school students in a food safety class found that students performed significantly better on tests with song-related questions than those who did not hear the songs (Winter et al. 2009). Additionally, a piloted curriculum at the university-level anecdotally found that when music was involved in learning economics, students tended to pay better attention and act more engaged with the material (Tinari and Khandke 2000). One teacher also found that playing music in her science classroom provoked recall of facts and skills her students have previously learned (Molyneux 2007). While this is not an extensive research list, these studies do indicate the efficacy of using music to teach science in the classroom.

Authentic tasks are defined as tasks that can "encompass everyday situations" that make clear connections to "real life," or life outside of school (Harris and Marx 2009). Authentic tasks are not common in school, but research and educational theory suggests their value in engaging students. John Dewey, a well-known educator and philosopher, advocated for the use of authentic tasks to allow students to delve deeper into subject matter and apply their logical reasoning and self-regulation skills. Dewey believed that students should learn through purposeful activity and "real-world tasks" that would seem purposeful and useful to students (Dewey and Childs 1933). This idea has been supported, as it has been found that cognitive engagement is not only dependent on the task itself, but on the context in which it is performed, called situated cognition (Brown et al. 1989). When tasks are situated in real-world contexts, students are more likely to be motivated, which can lead to increased cognitive engagement and increased learning (Harris and Marx 2009; Blumenfeld et al. 2006). Additionally, this authenticity may hold importance for students from diverse backgrounds, especially those whose language and cultural backgrounds are different from the mainstream and who may not see the everyday connections between schools and their interests and lives (Harris and Marx 2009).

Thus, by using a science web-series geared towards the TEKS, I hope to engage the Net Generation through the use of technology, as well as through the effective pedagogical practices of humor, music, and authentic tasks. In theory, this web-series should decrease the amount of pressure on teachers due to STAAR testing by allowing them to teach more content in a shorter amount of time, and it should also alleviate the disengagement that students feel with test-driven curricula.

Materials and Methods

Mid-July of 2016, I first began making the videos by making the introductory sequence, for which I used a Zoom H2 recorder and a DSLR camera. Both were checked out from the St. Edward's University Library. After recording the song and snapping stop-motion pictures, I then used Garageband and an iPad application called Stop Motion in order to edit the song and the stop motion video, respectively.

After making the introductory sequence, I then acquired lesson plans from Shelly Sellars at Covington Middle School in Austin Independent School District for the DNA and Chromosomes section of 7th grade Life Science. Based off of the objectives, TEKS, and main ideas and activities from the lesson plans, I then began to script my episode over the course of several days; I then sent it to my thesis advisor, Steven Fletcher, for approval. After getting the script approved, I began filming my series using a Canon Vixia HF200 camcorder and a Zoom H2 microphone, both of which I checked out from the St. Edward's University Library. The filming sites that I used were a classroom in Fleck Hall at St. Edward's University and my apartment, in order to keep costs low.

After filming over the course of several days, I used iMovie to edit the videos over the course of several days, and once I completed editing, I sent the video to my graphic designer Gerardo Silguero to add in graphics to the voice-over parts of my videos. Once this episode was complete and approved by my advisor, I presented it at the Austin Area STEM Conference on August 2 to several teachers and received feedback on how to improve the next episode.

I began work on the next episode over work, force, and energy at the beginning of September using the same scripting, filming, and editing processes, and I then I presented both finished videos to a focus group of college peers in order to gain feedback about the videos and their educational efficacy and engagement.

Findings

A focus group showing was conducted on 10 college students ranging from ages 19-23. A brief explanation of the cause and reason for the videos was given (to engage middle school students and also allow for an optimal amount of instruction in a minimal amount of time), and the videos were shown back-to-back. The first video was an 8-minute video on DNA and chromosomes, and the second video was a 17-minute video on work, force, and energy. The showings were followed by a survey and a brief discussion on the strengths and the weaknesses of the videos.

Table 1. Majors of focus group attendees.

Majors	Number of attendees
Psychology	1
Liberal Studies	1
Religious & Theological Studies	2
Political Science	2
Environmental Science and Policy	1
Neuroscience	1
Graphic design	1
Biology	1

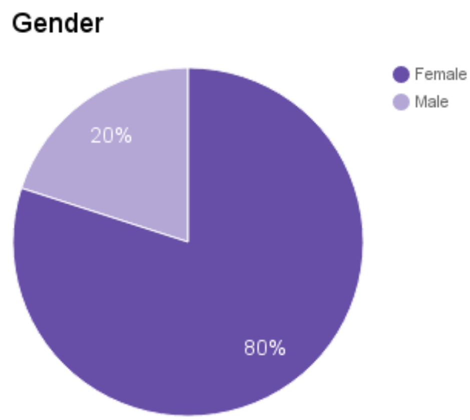

Figure 1. Gender of focus gr

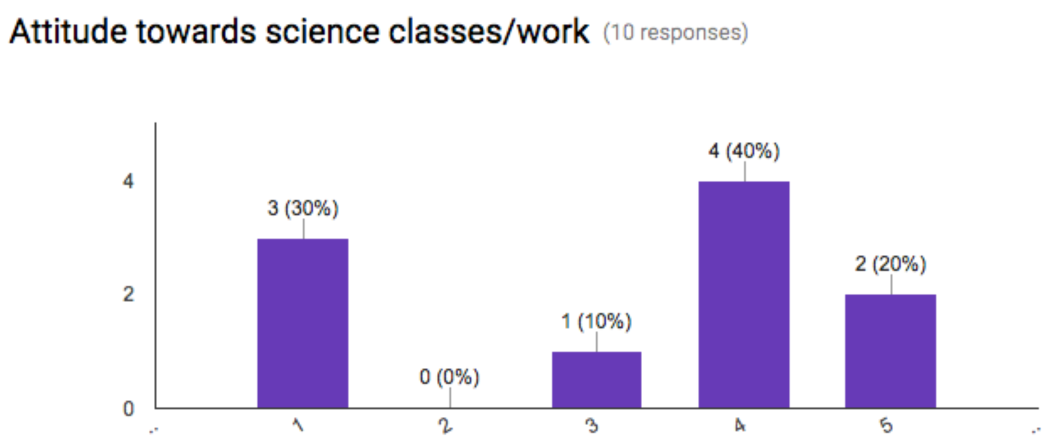

Figure 2. Attitude towards science classes/work scored on a Likert-like scale from 1-5, with 1 described as "I do not like science classes/coursework" and 5 described as "I enjoy science classes/course work a lot."

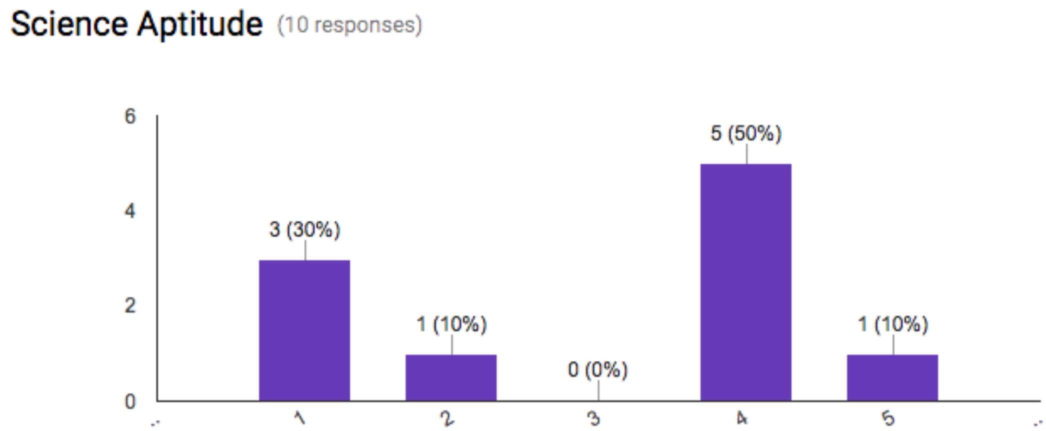

Figure 3. Science aptitude scored on a Likert-like scale from 1-5, with 1 described as "I do not do well in science courses/with science concepts" and 5 described as "I do extremely well in science courses/classes."

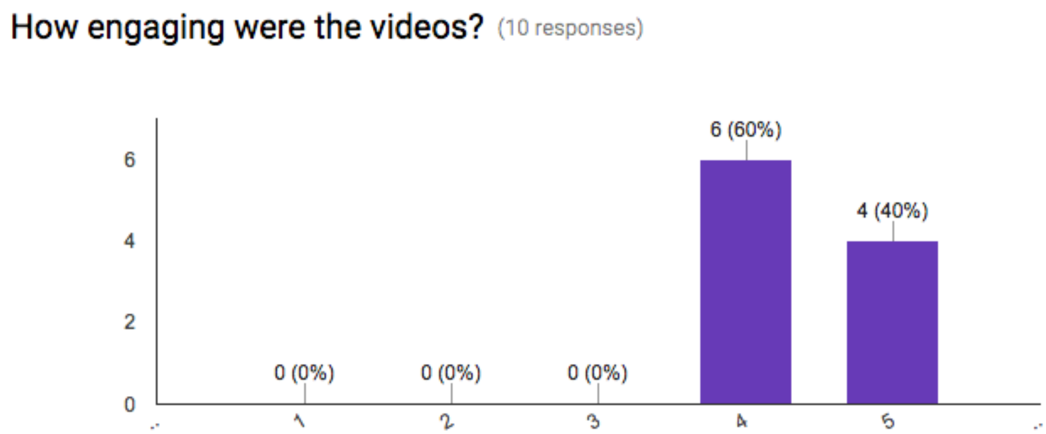

Figure 4. Video engagement ranked on a Likert-like scale from 1-5, with 1 described as “Not engaging at all” and 5 described as “Very engaging.”

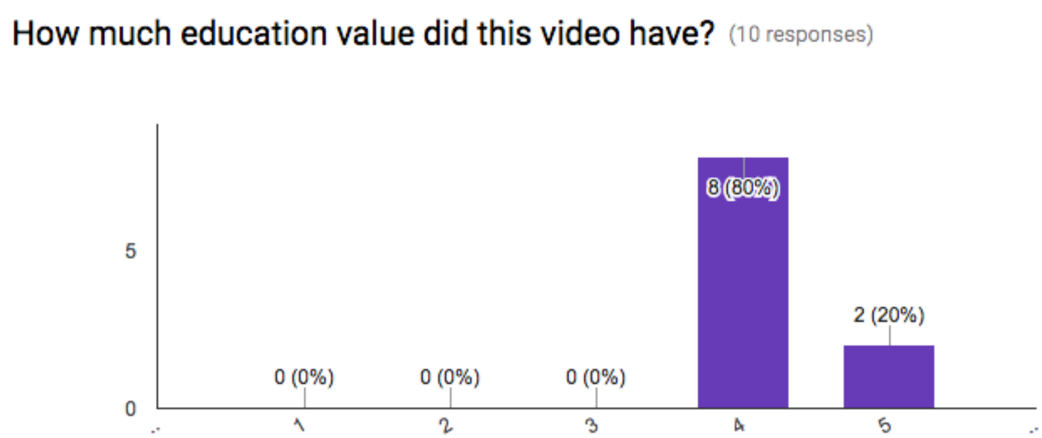

Figure 5. Educational value of videos as ranked on a Likert-like scale from 1-5, with 1 described as “This was not useful in helping me learn basic concepts of science” and 5 as “This was very useful in helping me learn some basic concepts of science.”

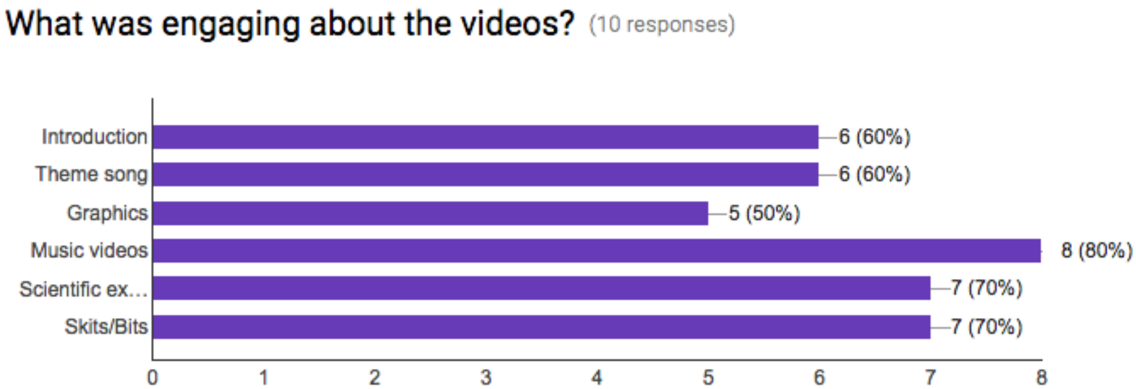

Figure 6. Engaging elements of the videos, as selected from a given list, including "Introduction," "Theme Song," "Graphics," "Music Videos," "Scientific explanations," and "Skits/Bits."

Themes

Some emerging themes from the data and discussion were the value of humor to increase engagement, as well as the utilization of multiple modes such as lecture, subtitles, graphics, and music in order to appeal to a diverse group.

Discussion

One of the recurring themes that was brought up in the feedback and the discussion was the use of humor in the videos. In the survey, humor was ranked the second highest engagement tool in the videos. One of the first comments from the group discussion after the viewing was, "You use humor really well," and the group agreed that humor was well-balanced with educational content within the videos. Another member of the group said that "[b]eing able to laugh at yourself makes people more comfortable with you." Humor appeared to make the science more relatable to the group, as the same students that mentioned that they did not enjoy learning about science said that they thought the videos were very funny and engaging.

Another recurring theme in the data was success in using varied methods to communicate content, such as the music videos and graphics. The survey ranked the music videos as the most engaging element of the videos. The group anecdotally seemed to be very excited when the music videos at the end, and they seemed to appreciate the original song more than the parody of a popular song. I think this could tie back into making science relatable; just as in the humor example, the group enjoyed my ability to authentically laugh and make fun of myself, the original song may have felt more relatable and authentic to the group than a parody. The usefulness of graphics was brought up several times throughout the post-viewing discussion. All though it was ranked as the least engaging element of the video, the group overall agreed in the discussion that they enjoyed the use of graphics in the video, and they felt that it helped them have a more concrete understanding of things, mentioning that the "graphics were really great," and "hearing as well as seeing...made everything a lot clearer."

Some of the suggestions included subtitles for the songs, as some felt they would have been better able to understand the content and appreciate the humor with subtitles. Additionally, the use of pacing came into play with the second video. The second video was much longer than the first one, and it also covered a lot more material than the first one. Some felt that varying talking speeds and tones, as well as breaking up the video into sections, would have facilitated better learning, as some of the viewers got lost during the second video. This is in agreement with the cognitive information processing theory mentioned in the literature review, as the audience could only pay attention for so long and only process so much information at once. Additionally, Middendorf and Kalish suggested that students can only pay attention for 10-15 minutes during a lecture (1996), but from this evidence, I believe that for students these days that the attention span is even shorter.

Implications

I learned that multiple modes of presentation of content are especially helpful to engage learners, and the more modes utilized within a video, the more diverse of an audience the video can reach. Some future additions to the videos I would like to add are closed-captioning options and subtitles for the music videos. This would help those who prefer to read, along with those who are auditory learners, and it would further diversify the learning audience the videos could reach. This video can also be modified to have Spanish subtitles for ESL students. The usefulness of this video lies mainly in the ways that it can be modified by me and also by the audience to benefit the learner to the highest extent possible, as they can watch and rewatch it as many times as they like, which allows for a more equitable dissemination of knowledge as opposed to the typical lecture format in classes.

Another modification I would make to the video is the length or pacing of the video. Even college students were having a hard time engaging with the video for 17 minutes, and they were getting confused by so much information at once. I could better block the content by adding more pauses in between lecturing bits, just so that there is a change of pace and viewers can stay engaged.

Something else to take into account is the sense of humor that would resonate with the targeted audience. One of the skits, “Newton’s Laws and Order SVU” was very resonant with the focus group, but one of the members mentioned that they were not sure if seventh graders would understand that reference. I have to be cognizant of the age gap between the middle school students and myself as I teach them.

In conclusion, I have found convincing evidence that these videos could be used to either supplement a lecture, replace a lecture, or even in a flipped classroom as the homework for the students to complete the day before. I believe that if I had the time and funding to really expand the series to more than two episodes, it could be very useful to teachers within Austin ISD. I believe that if teachers feel compelled to create their own videos for their own classrooms as supplements or replacements for lecture, they should do so, as their audience will probably appreciate their time and effort and find the videos engaging and motivating.

Appendix

Conversation bits:

“You use humor really well,”

“Being able to laugh at yourself makes people more comfortable with you”

“Educationally relevant”

“Seventh-graders would see the balance really well”

“For me personally, it was harder for me to get in the humor”

“Graphics were really great” “Hearing as well as seeing...made everything a lot clearer”

“I actually liked the second video a lot more. If I was a teacher, and I had to play a video...that video did a lot more for me than the first video...if the purpose of the video was to incorporate into your lesson plans...the second one did more.”

“I got really confused in the second video, equations of work and force, and then you brought in Newton...I think that if you included the equations”

“Is there gonna be a worksheet attached to this?”

“Maybe breaking down the episode....you talked a lot.”

“SVU skit was funny, but a little confusing.”

“I thought it was funny, too, I don’t know if 7th graders are gonna get it.”

“Maybe more tone variance with all your speaking.”

“For me it was subtitles in the songs”

“Include a closed-captioning option”

“In your intro...put ‘with Miss Ontai’ at the bottom”

“Do you have a set outfit?...Bill Nye always wears a lab coat”

“Were those necklaces yours?”

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