

BOARD # 60: Work in Progress: Learning how to develop engineering education videos: A beginner's perspective

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Abstract

Educational videos can be an impactful means of sharing engineering curriculum to a broader audience. Videos provide opportunities to compartmentalize information and take audiences on journeys beyond their local communities. However, one of the biggest challenges is how to develop these videos. Although the material is technical in nature, the discussion and approach cannot follow the same structure or delivery as a typical course lecture. The paper herein follows the journey of a civil engineering educator in the establishment and development of a series of educational videos on YouTube. With an identified goal to expand the broader public's view of civil engineering and the newly developing sub-fields of structural resilience, bringing engineering to life takes many forms. This work examines the steps in establishing the protocols for proper assessment, story boarding concepts, executing video plans, bringing these videos to life through careful editing, and general lessons learned in developing video themes. Technical theory is a cornerstone of engineering curriculum but can be quite unapproachable as it requires prior knowledge and familiarity with field specific language. Systematically building up context and breaking down subject matters into more digestible pieces of information support the audience's ability to connect with material and begin to identify key field specific terminology. Beyond the technical knowledge, it is essential to humanize the field and expand audience's perspective of who engineers are. With growing interest in social media, a major element of this is the social perspective and the curiosity of how engineers can be social individuals within their respective communities. To do this, the educational videos share ways engineers communicate and network through events such as conferences. The development of educational videos is not a straightforward process nor is there one correct approach. Rather, it is a journey of evaluating the educational goals and embracing the ability of video to transcend time and space to bring engineering to life.

1. Introduction

Education has evolved significantly from traditional textbooks and chalkboard lessons to more technologically involved engagements. Although the majority of these experiences are communal such as using PowerPoint slides or live demonstrations in a classroom, there is increasing presence of individual educational experiences such as virtual reality and video platforms.

Studies shown college students and educators are heavily using video platforms such as YouTube as an educational resource with one study showing nearly 90% of students falling into this category of us [1]-[4]. Studies show that nearly 90% of college students and instructors today refer to video platforms as an educational resource [5]. Although it may be seen as a temporary trend, the reality is that video references are becoming increasingly commonplace creating a need for more educators to participate in video development. From the perspective of content creation, demonstrating the use of a tool or the reaction of two chemicals are straightforward concepts that can be easily filmed. However, engineering educators are faced with the additional challenge of presenting more abstract materials that are loaded with industry specific jargon and knowledge prerequisites. Although these challenges seem comparable to standard lectures, the reality is that content creation must view these topics from a different perspective and approach due to time limits and need to continue audience engagement.

Considering these factors, this paper focuses on a civil engineering educator's experience in beginning a YouTube channel focused on structural resilience. As part of a National Science Foundation (NSF) CAREER project, this YouTube channel is under development to increase engineering students and the broader community's understanding of structural resilience and its relationship with the performance of new structural systems. As this is a work in progress, this paper brings together the beginner's perspective of this venture and the realities associated with planning video content for educational purposes. The following sections will discuss the motivation for video development, along with the planning approaches for content creation in order to support engineering educators' efforts in expanding their student engagement.

2. Background

YouTube was founded in 2005 with the goal of allowing content creators to broadcast themselves to increase their social network [3]. Today, there are over 4.3 billion YouTube videos [6] currently available. In 2018, Pew (a nonpartisan think tank) conducted a study that showed over 51% of viewers are there for education purposes [7]. Claiborne et. al [8] and work out of Vanderbilt University [9] has noted that there is a growing need to engage with students beyond communal classroom experiences and begin evolving the development of educational videos.

Educational videos can be an impactful means of sharing engineering curriculum to a broader audience. With the success of Math and Science channels such as Khan Academy, research is showing that these videos can serve as supplemental resources [10]. Educational videos are not a new concept but the changing environment is related to the approach and length. On average, a YouTube video is 7 to 15 minutes long [11]. That is significantly shorter than one would expect and far shorter than any educator would envision teaching a key concept. Most documentaries or

movie style educational films tend to be on the order of 75 to 120 minutes long [12], and lectures tend to run from 45 to 90 minutes. However, these formats are no longer the sole educational resource for most students. Worst of all is that viewers tend to decide whether to stay or watch a video within the first 30 seconds [13] [14]. Even with shorter videos around 5 minutes long, the retention rate is still around 60-70% [15]. This is a major constraint and burden for educator content creators due to the need to be as impactful as possible within the shortest time available. An adult learner's attention span for an in-person lecture is 15 to 20 minutes, which is significantly longer than statistics are showing for video content. As a result, we must recognize as educators that we are severely disadvantaged in video resources [16].

Educational videos have the potential of reaching various student learners [17]; instill 21st Century skills [18]; expand classroom boundaries [19] and not only heighten, but increase repeatability of emotions that excite, teach, and engage students [20] [21]. There is a need for these videos in engineering across all disciplines to teach complex and many times dense theoretical curriculum. Specifically, civil engineering can be a very difficult subject matter given the scale of projects associated with its application. For example, students cannot hold pieces of structural beams or columns in their hand for inspection; cannot easily expose building components for visual observation; and many times cannot readily access engineering offices or sites to get first hand context motivating their degree pathway. This creates a significant disconnect in reaching students who need that broad course perspective. It also can be cumbersome to engineering educators who want to bring lessons to life but lack the institutional resources to execute demonstrations. Additionally, there are physical boundaries to classroom lessons as the majority of our work is confined to the classroom space. To overcome this disconnect, content creation for educational videos can serve as a bridge to these challenges and bring engineering lessons to life.

As noted above, there are numerous challenges to this goal. The following will explore ways that engineering educators can leverage the many techniques being currently employed in content creation and infuse their skills as educators into the final products.

3. Planning Process

The expanse of engineering curriculum is quite broad with each discipline having its own inherent challenges and advantages in the development of engaging curriculum. Considering this, the following examines various methods of engineering content creation highlighting the benefits and disadvantages. It is recommended that each engineering educator evaluate these methods within the context of their discipline. Additionally, before diving into any content creation for an entire channel or a single video, it is imperative that learning objectives are defined. Learning objectives are defined goals that are set forth for what the students, in this case our viewers, are expected to retain from the lesson. Studies show that having defined learning objectives help guide the learning process and increase the rates of success [22]. Once these objectives are defined, careful consideration is necessary for the following subjects in the planning stage of content creation.

3.1 Video Length

This is the most challenging element of content design. Traditional lectures have a progressive approach with respect to student engagement. There is time for students to ease into the material, listen to technical discussion and potentially exercise that work within the confines of the classroom either individually or communally. As engineering educators, each lecture has defined learning objectives which are highlighted and potentially summarized at the beginning and end of lectures. However, considering all of the activities mentioned above, this requires time to manage each of the various lecture elements. Unfortunately, as discussed previously, time is not on our side with respect to developing educational videos.

Although videos on most platforms can range in length from 5 to 60 minutes, the predominant approach is to create shorter videos around the 5-minute mark. The reason for the range in video length is that studies show shorter videos tend to help with viewer engagement [23]-[25]. Considering this time constraint, these shorter videos allow material to be broken down into digestible portions that emphasize a specific piece of content or information. But this does not mean that longer videos are no longer an option at all.

Studies show that viewers interact more with longer videos [26]. But the key element is maintaining viewer attention or increasing retention rates. Breaking down complex topics into digestible pieces and employing longer video times seem like a logical approach, but exactly how this can be achieved is our next discussion.

3.2 Video types

While lectures that involve writing on a projector screen or board suffice in a classroom setting, educators must be more creative when it comes to video content. Unfortunately, our traditional lectures will not easily translate from classroom to online platforms that easily; but all is not lost. Rather, engineering educators must understand what exactly are students looking for in the discussion of the topics and what elements of our lectures should be transferred into repeatable video resources.

Lab Demos – With lab demonstrations being a major factor in numerous engineering disciplines [27], students are required to be able to exhibit various skills such as soldering, determining the correct placement of electrical/mechanical pieces to complete a circuit, or in the context of civil engineering work, knowing how a material will behave under different loading conditions. In all of these scenarios, there is a major element at hand which is the resources or tools available. Many institutions may have limited resources allowing for select lab work and/or a restrained number of times certain work can be performed with the supplies available. As such, studies show that even by watching another person conduct an experiment there is an immense increase in material reinforcement compared to purely reading about the process [28]. Considering this, one of the ways engineering educators can help reinforce this is by utilizing lab demonstrations as a means of creating repeatable experiences for students via video.

Saville [29] and Wiggins et. al [30] noted that repetition increases the likelihood of comprehension further increasing the chances of success. These videos can be created by setting

up a phone camera or regular camera during a lab demonstration and filming the entire process. Although this may seem like a long video which may include various points of minimal activity, this can be fixed using creative editing to speed up or slow down certain steps in the process. But it is important to recognize that these demo videos do not need to be especially complicated. Instead, they capture key exercises that become repeatable assets overcoming challenges with time and resources.

Large Scale Experiments - Building upon lab demonstrations, we must discuss large scale experiments. For civil engineers, large scale testing is a rare and expensive opportunity. This is due to the fact that the specific machinery required to conduct tests such as shake table testing or replication of earthquake ground motions for scaled or full-scale structures can be found at select facilities nationwide. In some cases, civil engineering researchers find ways to participate in large experimental tests via payloads which can be the addition of a design element, instrument, or piece of content to the existing project which is far more economically feasible. These large tests can be very motivating and impactful to students for a number of reasons. They bring to life the technical theory and highlight the importance of their work by exemplifying (many times in dramatic manner) the results of structural failure contrasted against alternative design approaches. These awe-inspiring moments have proven to be effective means of motivating students' degree pathway and encouraging their interests in their field [31]. Across the board, this context of large-scale experiments can be found in many forms throughout the engineering disciplines. The essence of a "large" experiment could be from the perspective of the number of specimens tested, the equipment size, or even the necessity to utilize special testing facilities. But a major limitation is that the majority of these tests are done without much public distribution even after the work has been published in technical journals. This is a lost resource which could have immense impact beyond the immediate Universities involved.

Video Logs or Vlogs – Most people are familiar with vlogs nowadays in the form of video journals which chronicle a person's daily activities, thoughts/opinions, or experiences. Although this might seem mundane, this is an untapped resource for engineering educators. Studies have shown that students have a positive attitude towards vlogs although most of the research conducted in higher education has focused on reflective practices [32] [33]. Interestingly enough, research has shown an improvement in students' response especially with regards to language subject matters including English as Second Language (ESL) curriculum [34] [35].

Lessons – Now, although traditional lecturing is not going to be a top viewer draw, there still is a time and place for engagement through simple graphics and text. PowerPoint slides have shown to be beneficial effective in courses when done appropriately [36]. As such, this presents the case that not everything has to be a visit to a location or eventful exercise. Content should be reflective of its intended goal. In this case, this could be the introduction of terminology or the overview of a process. For the author, her channel is focused on presenting to the public a new area of structural engineering emphasizing sustainability. What this means is that there will be new terms used from both fields that must be established. It also includes understanding the context of motivation for experts in sustainability and structural engineering to allow the viewers to better appreciate the direction of work and future of the field. Although much of this will be exemplified through vlogs and other visually active videos, students many times need explicit

instruction [37]. Studies show that students do benefit from plain introductions of materials with direct facts presented to establish as a foundation.

3.3 Creating the Story

Having identified the overarching concept and time constraint for the video content leaves the final step of outlining the material needed. This material comprises the still and action scenes required to bring together the video's concept and message. One of the biggest mistakes that can be made is randomly taking short recordings and photos with the hopes that it will encompass everything that is needed. When educators will be conducting visits or work (i.e. experiments, demonstrations) that will be difficult to revisit and duplicate, it is essential to plan ahead the necessary angles and information that must be gathered to create a fully story.

Each video created is a story. There is a beginning, middle and end to the content. As engineering educators, we know having a cohesive lesson is a major contributor to successful student engagement [38]-[40]. Considering this, educational videos need to have a complete story that is self-contained. Although this might seem quite straight forward, the reality is that lectures are connected very much to a broader course goal. As such, there is information from a previous lecture that leads into the current one as well as material that will be carried forward. However, within the context of a video, the educator cannot assume that the viewer will have watched all the videos prior to the one being presented. As a result, this presents another challenge of being able to create a sense of continuation and completeness.

One of the ways to work with this constraint is to story board a concept. This is the process of laying out all the material into a streamlined fashion such that the educator creator can visually see the chronological order that the material will be presented. This is a critical step in the content process which is similar and dissimilar from lecture development. In terms of similarity, there will be an overarching goal of the video that will drive the material covered. With this, the educator can either bullet point or create small, simple drawings of what will be covered in each segment of the video. This is comparable to the development of lecture notes. The visual element to laying out the chronological order of material helps the educator creator to visually see the transition of the material. Also, we can leverage the technique of identifying points in lectures where various exercises or discussions would be introduced to help us define points where viewer engagement is needed. This component is where the process does diverge from traditional lecture note creation. In this scenario, the engagement is no longer a question proposed to the class or a brief group discussion/exercise. Rather, this could be a snapshot of a visual aide or even a short video taken of a specific process, location, or other clarifying subject matter. All of these small details as well as the main video content must be planned out for recording. Thus, the story boarding helps the educator creator identify what pieces of information he/she will need to gather throughout their recording process.

4. Case Study

This paper's author is currently developing the YouTube Channel Engineering with Jen (@engineeringwithjen). The channel is part of an educational objective for an NSF CAREER grant with the mission to expand the knowledge base of structural resilience and new structural

engineering sub-fields. This key objective was tied to technical research and an identified need in the civil engineering curriculum to create new video material as discussions related to these subject matters were very limited. With new design concepts emerging in structural engineering, there has been limited research due to the pace of technological development and public acceptance. As a result, this has led to numerous design features such as rooftop gardens and vertical landscaping to be implemented with limited cross-over and collaboration between researchers and the practicing engineering community. Within this theme, there is a lot of room for discussion given that it is the first-of-its-kind in development. This situation is both advantageous and disadvantageous as it presents an ample number of ideas for video development but also means that the knowledge base on the material needs to be built up. To develop the necessary knowledge base and begin a viewer community, the author is working on a variety of videos.

Video Length – Based on the author’s research, the initial videos drafted focus on a 5 to 10 minute length. This will allow her to highlight and focus in on specific systems for which the narration can help guide the viewer in better understanding both the terminology as well as some of the fundamental engineering elements. This initial length was selected as the author needs to establish a viewing community and refine her skills in video engagement. However, she will test longer length videos in the future to allow for better assessment and comparison in viewership and general reception. Additionally, as her channel progresses, the goal is to develop playlists for viewers to watch videos consecutively that are related to each other.

Video Types - The first step in the planning process was identifying the types of videos that would make the best first impressions with new viewers. The technical matter can be seen as very abstract and unapproachable so the goal was to create initial video content that would be easily digestible and comparable to what viewers look to in recreational watching. Additionally, civil engineers many times are associated with grand, complex designs whether they be bridges, skyscrapers, or extensive water resource systems. But the reality is that civil, along with other engineering disciplines, have their products visible and present in our lives from the moment we wake up.

For this reason, the author is creating vlogs that bring viewers to locations in Europe and Asia that highlight rooftop gardens (parklike environments) and vegetated walls. Both of these elements are very aesthetically pleasing which draw passerby’s attention yet few fully understand the structural concepts behind their design and development. These videos create a travel experience while introducing technical language that will be further explored in future videos but is introduced with direct examples. It covers concepts such as loadings or the forces that must be considered in member selection as well as identifying key structural systems. The concepts of the videos are very approachable and do not require specific levels of engineering knowledge. As such, these initial examples of structural design are serving as a platform to motivate viewers to learn more about their design development and continue following the channel to learn more of the technical material.

One example of this approach is from a video drafted for the vegetated wall at the Caxia Forum in Madrid, Spain. This is a 78-foot wall located along the busy Paseo del Prado corridor. It is an excellent example of modern structural design that incorporates landscaping into the wall which

allows the author to highlight both in her technical and educational research. However, it is impressive to note that the wall is very much overlooked by the public. During the filming of the wall, many people at first passed it by without a second look. But when they noticed the filming, people began to stop and look at it more closely. This very reaction is one of the targeted goals in the video, which is to bring viewers' attention to perceived ordinary systems that actually have very complex and innovative designs.

Another example within this same context is a vlog for a multi-level rooftop garden in Tokyo, Japan. This garden sits atop a very stylish and new multi-level mall in the Harajuku district. With the use of full-sized plants and trees, the garden is concentrated on one corner of the structure across several floors. This amazingly intricate garden presents an opportunity for the author to discuss the design considerations needed to create this visual spectacle from the structural detailing of the tree anchors and wall cladding to even the placement of the garden as a whole.

Although the majority of the first videos drafted focused on the vlog style, several videos in the distribution queue focus on a different video type. One video is a lab demonstration of a small-scale test of a rooftop garden structure to capture damping effects. This video focuses on terminology such as damping while visually showcasing its effects on a structure. In contrast, another video uses PowerPoint slides with static images to discuss terminology such as structural resilience. Both of these videos in queue are emphasizing technical terminology but through two different approaches: demonstration versus lecture-like presentations. This approach is intentional to allow the author an opportunity to assess viewer response and engagement.

At the time of this paper, the channel is still under development with the first videos being posted. As such, the author plans to follow up this paper with feedback and assessment results as well as lessons learned on the progress of the channel and the application of the approaches discussed above.

5. Conclusion

The engineering curriculum is a complicated subject matter not only due to its intrinsic technical base but the necessity to broaden student perspectives using examples whether through real applications or laboratory experiments/demonstrations. Bridging the gap in resource access is an immense challenge felt by numerous institutions nationwide. Additionally, with the general change in students' perspectives of reliable educational resources, engineering students will increasingly seek assistance from video content.

Considering all of these factors, it is a critical time for engineering educators to become a part of the content creator communities. Utilizing our wealth of knowledge and skill in the classroom, we have the potential to increase our impact and share the resources across our entire disciplines. But as seen through the discussions above is not a straight forward process of taking our traditional lectures and recording them. Although there may be benefits of having recorded traditional lectures available, the research is showing that viewers have very specific needs with their mindset being different from an in-person lecture. As such, it is imperative that engineering educators begin to navigate this process and better understand what elements of their courses

currently can translate easily to video content. As well as identify what material needs to be viewed from a different perspective to make it suitable for repeatable viewing.

This is not a straightforward process and fortunately has many venues for development. As experienced through the author's development of her channel, she is experimenting with the content and approaches that will be best suited for her students' needs. There is much anticipation to track student and viewer reception of the material as the channel develops and builds a learning community in the coming year.

Overall, educational videos are an excellent opportunity to transcend the classroom walls and bring our engineering knowledge not only to engineering students but the broader public. This can increase the effectiveness of our work by reinforcing the motivations and approaches to solving engineering problems. It has the potential to expose students to engineering for the first time in their lives creating the next generation of engineering students. Even more so, a growing community of engineering educator content creators can allow us to leverage the resources available at our respective institutions and bridge the gap in access by sharing demonstrations and projects that can reinforce and build up our course curriculum.

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