Student and Instructor Perceptions of Online Engineering Education Videos

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Abstract

With increasing technological development and wide accessibility of online video content, there has been a corresponding increase in the production and integration of online screencast tutorials in higher education courses. Screencast tutorials are being used to provide and to support instruction at all grade levels (K-12 and college) in online and blended learning environments; we specifically focus on engineering in our study.

The predominant use of online videos by engineering students has been to seek out specific course related tutorial videos to support their learning or to supplement content in traditional teaching courses. However, the characteristics of an effective screencast tutorial for teaching purposes are not well-defined (i.e., is it enough to work an example problem step-by-step in a 5 to 15-minute video or record an entire classroom session on a tablet PC?). In this paper, the survey results of engineering and student instructor perceptions of use and characteristics of online engineering video tutorials are presented. Based on survey results, students are most likely to utilize online video tutorials to complete homework assignments and prepare for exams. Students and instructors consider organization (as characterized by step-by-step, clear, concise) to be the most valued characteristic of quality engineering video tutorials. In addition, specific recommendations are provided, which individual instructors can implement to create effective engineering video tutorials.

INTRODUCTION

The growth in popularity of video sharing websites such as YouTube and the increase in available bandwidth, have played a major role in the accessibility of online education videos that allow students to watch and learn on their own time [1]. Online video supplemental instruction is increasingly being integrated in higher education, with evidence that video in education can improve comprehension, retention, discovery, and accessibility [1]-[5].

Screencast tutorials, which are video captures of a tablet PC with voice narration by the instructor, are widely available on YouTube in nearly every discipline. In engineering related videos, many of these tutorials are problem-based videos or worked examples intended to help students acquire problem solving skills [1],[5]. However, the characteristics of an effective screencast tutorial as desired by students to support engineering courses are not well-defined.

In this paper, our objectives are to describe and to compare student and instructor perceptions of the use of online video to support classroom instruction and identify the characteristics and features that constitute a quality engineering video tutorial. Perceptions of engineering instructors and students are investigated through surveys conducted at multiple conferences. In addition, the results of the survey analysis are used to provide recommendations for best practices on developing engineering video tutorials; particularly as it relates to the stages of the film production (i.e., pre-production, recording, and post-production).

PERCEPTIONS OF ONLINE VIDEO

During the 2016-17 academic year, several surveys of engineering students and engineering faculty were conducted during student conferences and educational workshops to characterize student and instructor perceptions of online engineering video tutorials. 54 undergraduate engineering students from public (37 students) and private universities (17 students) were surveyed during an engineering student conference hosted at University of the Pacific, Stockton, CA. To gain instructor perspectives, 43 engineering instructors from junior colleges and four-year universities were also surveyed during a general engineering educators conference at San Joaquin Delta Junior College and a materials science education symposium at University of California Berkeley. The audience surveys were conducted using polleverywhere.com with responses to questions submitted by mobile phone or computer.

For engineering students, the survey involved three questions listed in Table 1. The first question was an inquiry regarding their participation in flipped courses. The second question was a multiple-choice question regarding the use of online engineering education videos with the ability to select up to three options. The third question was an open-ended response question asking for audience opinions regarding the characteristics that make a "good" engineering screencast tutorial video.

For instructors, the survey also involved three questions listed in Table 1. The first question inquired about whether the instructor has ever made a video for any course they teach. The second question is like the student survey; however, instructors were prompted to respond to the question from a student's perspective. The third question was identical to the student survey.

Table 1. Survey Questions for Students and Instructors

	STUDENT QUESTIONS	INSTRUCTOR QUESTIONS
Q1:	Have you ever been a student in a flipped lecture or course?	Have you made a video to support a course you teach?
Q2:	For what purpose(s) do you use online engineering education videos? (choose up to 3 options) A) Homework Help B) Prepare for Lecture C) Videos Shown in Class D) Lecture Capture E) Test Prep (FE Exam, midterms, finals, etc.) F) Supplement Course Content G) Other	For what purpose(s) are students most likely to use online engineering education videos? (choose up to 3 options) A) Homework Help B) Prepare for Lecture C) Videos Shown in Class D) Lecture Capture E) Test Prep (FE Exam, midterms, finals, etc.) F) Supplement Course Content G) Other
Q3:	What qualities or characteristics make a good engineering video/tutorial?	What qualities or characteristics make a good engineering video/tutorial?

Student Participation in a Flipped Classroom
For student survey Q1 involving student participation in flipped courses, 53 of the 54 students responded. Of the 53, 18 (34%) indicated "yes" to having participated in a flipped classroom setting, while 35 (66%) indicated "no". The question was designed to determine the percentage of students who have participated in a flipped classroom environment and is not limited to engineering classrooms.

While this survey question is not a central topic of this paper, the low cost, ease of production and distribution of video tutorials has supported the adoption of a flipped classroom as a blended learning model; where videos are viewed outside of scheduled class time and face-to-face meetings are used for alternative strategies (e.g., instructor guided active learning, cooperative learning, peer led team learning, etc.) to promote deeper learning. A 2015 survey of higher education faculty indicates that 69.5% of respondents have flipped an activity, class, period, or course, and plan to implement the model again (Magna 2015).

Video Creation by Instructors
For instructor survey Q1, making of a video to support a course taught by the instructor, 43 responses were received. Of the 43, 18 (42%) instructors indicated "yes" to having created a video, while 25 (58%) indicated "no".

Use of Online Engineering Education Videos
Q2 on the survey inquired about the purpose for using online engineering education videos. Instructors were asked to answer this question from the student's perspective. For Q2, there were 140 total student responses and 91 total instructor responses. Participants could select up to three choices. Table 2 provides a summary of results.

Table 2. Responses for the Use of Online Screencast Tutorials, Q2

OPTIONS	STUDENT RESPONSES		INSTRUCTOR RESPONSES	
Homework help	47	33.57%	28	30.77%
Prepare for lecture	10	7.14%	8	8.79%
Videos shown in class	8	5.71%	7	7.69%
Lecture capture	4	2.86%	6	6.59%
Test prep	37	26.43%	31	34.07%
Supplement course content	21	15.00%	9	9.89%
Other	13	9.29%	2	2.20%

For students surveyed, the top three uses of online screencast tutorials were as follows:

- Homework help (33.57%)
- Preparation for tests (26.43%)
- Supplementing course content (15%).

Based on the instructor survey results, instructors believed that engineering students utilized screencast tutorials for the following uses:

- Preparation for tests (34.07%)
- Homework help (30.77%)
- Supplementing course content (9.89%)

The responses from engineering instructors and engineering students have agreement with respect to the top three uses of online engineering education videos. The predominant use of online education videos for homework help and exam preparation suggest that engineering students are using online videos to assist in solving engineering problems and seek to learn by worked examples from an "expert." Furthermore, there is reason to believe that engineering instructors understand the student needs and purposes for online engineering education videos.

Desired Qualities or Characteristics of Online Engineering Video Tutorials

Q3 on the survey was an open-ended question to compare student and instructor perceptions of the qualities and characteristics that constitute a "good" engineering video tutorial and serves as the main topic of this paper. This open-ended question compares the student and instructor perceptions of the features that constitute a quality screencast tutorial. There was a total of 42 responses from the 54 students surveyed and 60 responses from the 43 instructors surveyed. Participants in the survey could provide as many responses as desired. Since most responses were submitted via text message, survey participants responded with single words or short phrases.

As an initial review of the student and instructor responses, word clouds were generated using wordart.com to quickly gain a visual representation of responses and identify the characteristics that stood out for each group. The word clouds generated from student responses and instructor responses to question 3 are shown in Figure 1a and Figure 1b respectively.

(a) Student Responses (b) Instructor Responses

Figure 1. Desired Characteristics of Engineering Video Tutorials.

Based on the generated word clouds, it appears that students prefer step-by-step example problems, while instructors emphasize features such as short, entertaining, and clear. While the word clouds provide a preliminary analysis of open-ended survey responses, they fail to group words with similar meanings and words can be interpreted in the wrong context [6]. In this

paper, the word clouds provide an initial supplemental analysis to guide the direction for the following detailed text analysis.

To conduct a more thorough textural analysis, the open-ended responses provided by students and instructors were grouped into one of the following five categories: Instructor Presence, Organization, Visual Aids, Content, or Production Quality. The categories are listed below followed by sample responses.

- Instructor Presence – "energy", "funny", "entertaining", "enthusiastic"
- Organization – "short", "concise", "step-by-step", "well-explained"
- Visual Aids– "diagrams", "figures", "clear writing", "pretty"
- Content – "examples", "problem solving", "theory", "interesting"
- Production Quality – "audio quality", "mobile-friendly", "HD quality"

The words and phrases from student and instructor responses pertained to various aspects of content and delivery in video tutorials that are equally important for effective instruction and in developing an engaging classroom environment.

As listed in Table 3, the top two categories for students were organization/preparation at 40.5% and content at 31%. For instructors, the top category was also organization/preparation at 41.7% followed by instructor presence at 23.3%. For instructors, content was a close third at 21.7%. Figure 2 provides a graphical comparison of student and instructor responses.

Table 3. Count of Responses by Category.

	Count		**Percentage**	
CATEGORY	**Student**	**Instructor**	**Student**	**Instructor**
Instructor Presence	6	14	14.3%	23.3%
Organization	17	24	40.5%	41.7%
Visual Aids	6	2	14.3%	3.3%
Content	13	13	31.0%	21.7%
Production Quality	0	7	0%	10.0%

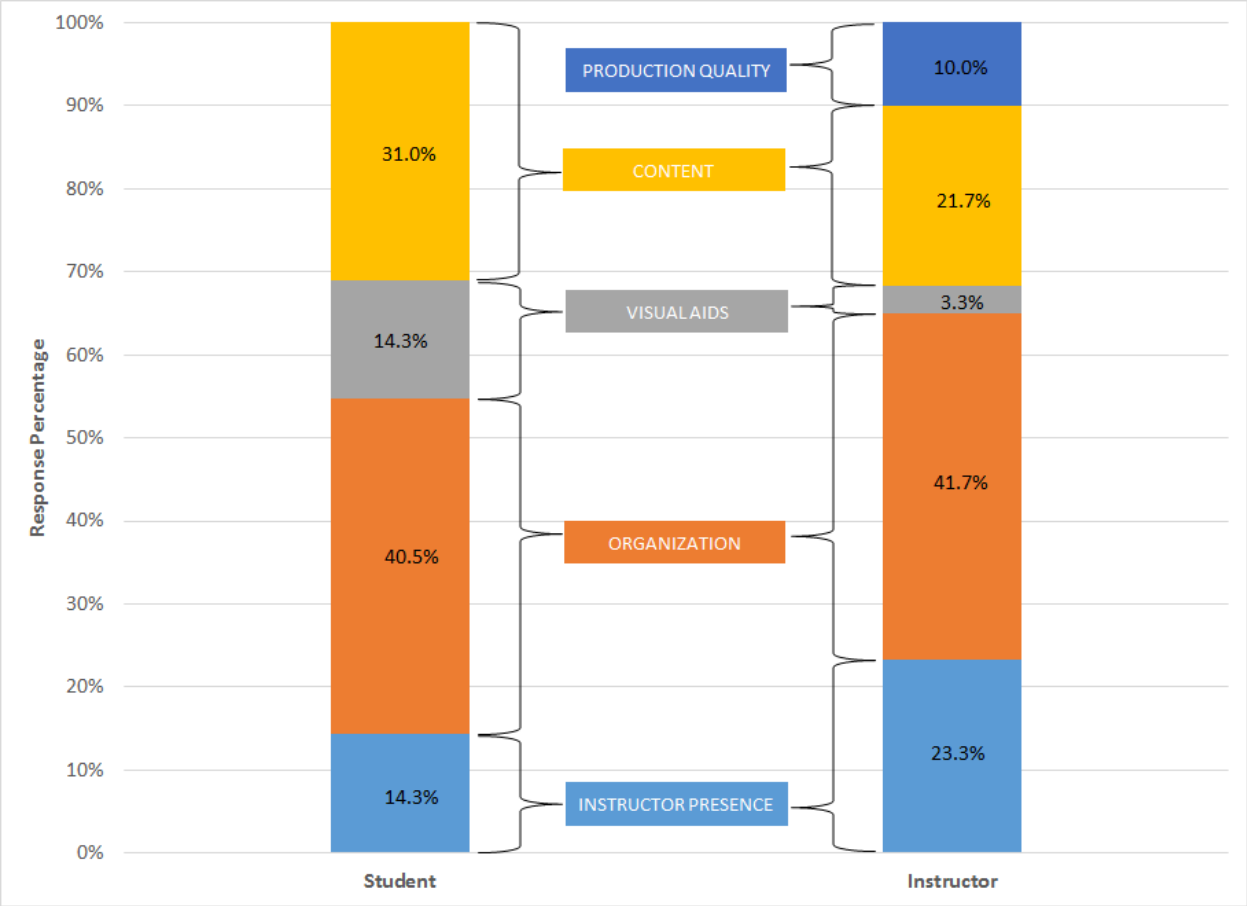

Figure 2. Comparison of Student and Instructor Responses for Q3

DETAILED TEXTUAL ANALYSIS OF Q3 RESPONSES

Organization

From Figure 2, it is evident that students and instructors both value organization in engineering education videos. Organization was considered the most important category based on total survey responses from the student and instructor groups with a total of 43 responses (17 student responses and 26 instructor responses). Responses related to organization were further divided into descriptive subcategories as summarized in Table 4.

Table 4. Subcategory Counts for Organization

Descriptive Subcategories	Sample Responses	Count	
		Students	Instructors
Conveys information succinctly	"short", "concise"	6	16
Does not contain mistakes	"error-free", "accurate"	2	1
Easy to comprehend	"straightforward", "clear"	3	7
Video is arranged in a systematic way	"step-by-step", "in-order"	4	1
Video is thorough	"detailed", "well thought-out"	2	1

The responses from instructors and students emphasized multiple subcategories related to organization, the top three listed below based on total response are:

1) Convey information succinctly – 22 total responses
2) Easy to comprehend – 10 total responses
3) Video is arranged in a systematic way – 5 total responses

Creating an organized video that is succinct, straightforward, and systematic shares many similarities with the processes associated with effective instructor lesson planning. Identifying an appropriate lesson objective accompanied by preparation and planning prior to recording is a critical step in the video production process in order fulfill the intended lesson objectives. Another important factor in creating a video that is "short" involves editing after recording, where various speaking tics such as "uhms" and "ahhhs" can be deleted; as well as writing out of equations and solving calculations can be compressed to be viewed rapidly to reduce "dead time" in a video.

Content

The content of an online engineering tutorial video was the second most important characteristic with a total of 26 responses (13 student and 13 instructor responses). Responses related to content were further divided into subcategories as summarized in Table 5.

Table 5. Subcategory Counts for Content

Descriptive Subcategories	Sample Responses	Count	
		Students	Instructors
Effectiveness of the video content	"interesting", "appropriate complexity"	1	6
Interacting with the viewer	"interactive", "allow check points"	0	4
Worked Examples	"problem solving", "examples"	11	3
Explanation of concept	"theory"	1	0

For students, worked examples were overwhelmingly the most desired content type with 11 of the 13 responses specifically stating "problem solving" or "examples" as an important characteristic of an online engineering video. The desire for worked examples is reasonable when considering that undergraduate engineering students are typically involved in courses that require the development of problem solving skills. Worked examples are a proven and popular approach to help learners build cognitive skills, particularly in the early stages of learning [7], [8]. In fact, students are known to bypass textual and verbal descriptions in favor of examples to complete problem assignments [8].

Amongst instructors, there was a distribution of responses related to content with an emphasis on the effectiveness of the video content and interacting with the viewer. These responses potentially reflect the importance instructors place on retaining the attention of the learner

throughout the video. There were no responses related to creating content that provides derivations or explanations of theory.

Instructor Presence

With 20 total responses (6 student 14 instructor responses), instructor presence was considered the third most important feature based on overall responses. Responses related to the instructor presence category were subcategorized as shown in Table 6.

Table 5. Subcategory Counts for Instructor Presence

Descriptive Subcategories	Sample Responses	Count	
		Students	Instructors
Ability to keep learner interested	"entertaining", "engaging"	0	4
Appropriate use of humor	"making it funny", "humor"	1	6
Knowledge of the subject matter	"knowledge"	0	1
Level of enthusiasm for the subject	"energy", "enthusiastic"	4	1
Speaking ability	"a good voice", "clear speech"	1	2

While student responses were focused on the ability of the instructor to convey enthusiasm for the subject, instructor responses stressed the inclusion of humor and ability to maintain the interest of the learner by being engaging and entertaining. The instructor responses again allude to the instructor's concerns on retaining the attention of the learner throughout the video. While speaking voice and body language are important factors influencing instructor presence during a classroom meeting, the speaking voice in a video tutorial is the most important factor in communicating excitement in the topic and maintaining the learners interest.

Visual Aids and Production Quality

Based on the student and instructor responses, the visual aids (8 total responses, 6 student and 2 instructor) and production quality (6 total responses, 0 student and 6 instructor) categories did not garner significant interest. In comparing the two categories, students seemed to favor visual aids over production quality, while faculty favored production quality over visual aids in online engineering education videos. Table 6 and Table 7 provide subcategory counts for the Visual Aids and Production Quality categories, respectively.

Table 6. Subcategory Counts for Visual Aids

Descriptive Subcategories	Sample Responses	Count	
		Students	Instructors
Attractiveness of figures and drawings	"pretty", "pretty diagrams", "nice looking"	1	2
Clarity of writing, figures, and drawings	"well-drawn diagrams", "clear writing"	2	0
Provides visuals	"figures", "visuals"	3	0

Students responses regarding visual aids emphasized the importance of providing figures and visuals to support the aim of the video. In addition, videos having clear-writing and well-drawn diagrams were considered important characteristics of the visual aids being used during the video.

Table 7. Subcategory Counts for Production Quality

Descriptive Subcategories	Sample Responses	Count	
		Students	Instructors
Audio Quality	"great audio quality", "sound quality"	0	3
Mobility	"mobile friendly"	0	1
Production Value	"good production values"	0	1

All responses related to production quality were from instructor responses. These responses emphasized sound quality of a video as well as mobility, production value, and video resolution. Although student responses did not consider the sound quality or video resolution, a minimum level of production quality is necessary in online education videos because without adequate video resolution or audio quality the viewer can be easily distracted from the learning objectives or the video content may not be accessible to the learner.

VIDEO TUTORIAL RECOMMENDATIONS

Creating online engineering video tutorials is analogous to the film making process, which is characterized by three distinct stages as shown in Figure 3. First is the pre-production or planning stage followed by the production stage or recording, and finishing with the post-production stage, which involves editing and sharing. Implementing these stages in video production or any project is not new and often requires a team of specialists in each phase to produce a high-quality video; however, many instructors lack the support personnel needed at each phase of video production. In this section, recommendations are provided for each of these stages based on the findings of the survey responses, specifically Q3, and the authors' learned experiences in creating over 200 online engineering video tutorials on a YouTube channel with over 90,000 subscribers (youtube.com/structurefree). The intent here is to emphasize critical aspects that can be implemented by a single instructor within the video production framework to efficiently produce videos that can enhance audience retention.

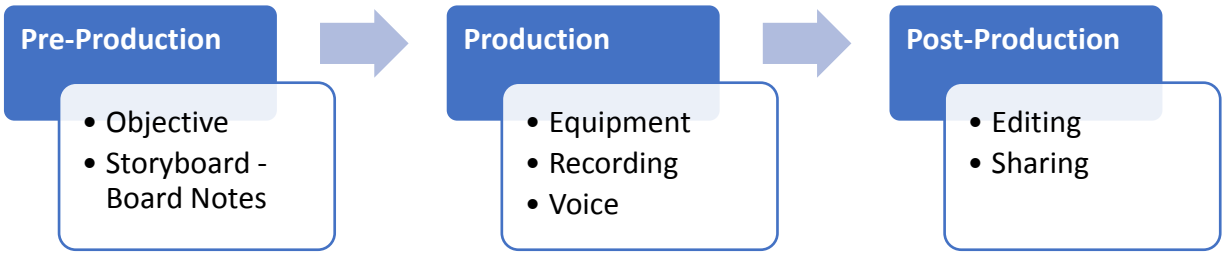

Figure 3. Video Production Process

Stage 1: Pre-production

Based on the survey results, the pre-production or planning stage is the most important aspect of the video making process since it directly influences its organization characteristics (convey information succinctly, minimize errors, and arranging video in a systematic way). Furthermore, the pre-production stage is critical in identifying the appropriate content type, level of

complexity, and methods to interact with the viewer. In this stage the following suggestions or steps are recommended:

Define one learning objective for the video tutorial

A significant quantity of literature exists supporting the importance of student learning objectives in education [9], [10] as well as guidance on best practices in writing learning objectives [10], [11].

Selecting one learning objective at the beginning of the video and explaining its relevance to the engineering discipline provides the viewer with a clear expectation of the content in the video and what is to be gained by watching the video. In addition, limiting the content of the video to a single learning objective assists the creator in identifying the type of video to create (e.g., problem solving, concept explanation, etc.), and limiting the amount of content in the video as not to overwhelm the viewer.

Create board notes as a storyboard before recording

Most of the pre-production stage of the video creation process involves planning the content that is to be presented in the video. The planning process generally involves segmenting the content into a step-by-step process, identifying key points, preparing visuals, drawings, and calculations [2]. Pre-planning allows the instructor to discretize complex concepts into manageable chunks [3]. Here we recommend the use of detailed, sequential board notes to organize the content to be seen by the viewer in a video tutorial.

Board notes are accurate handwritten representations of an entire classroom presentation, where an 8.5" by 11" sheet of paper is segmented into 4-6 rectangular panels representing a portion of the white board in a classroom [12]. Similar to story boards used in film production, board notes can be used to provide a layout of how a viewer would see the content in a video, complete with written text, illustrations, and calculations. In addition, prepared board notes can help to identify gaps in the information being presented or identify information that can be omitted from the video, ultimately saving time for the instructor throughout the entire production process. An example of board notes created for an example problem in mechanics of materials is shown in Figure 4.

Stage 2: Production – Recording

Use necessary hardware and software to make the video accessible

While video resolution and sound quality were not factors for students in a quality video tutorial, appropriate hardware and software are necessary to create a video that results in enough screen resolution and sound quality/volume so that production factors do not detract from the learning objective in the video.

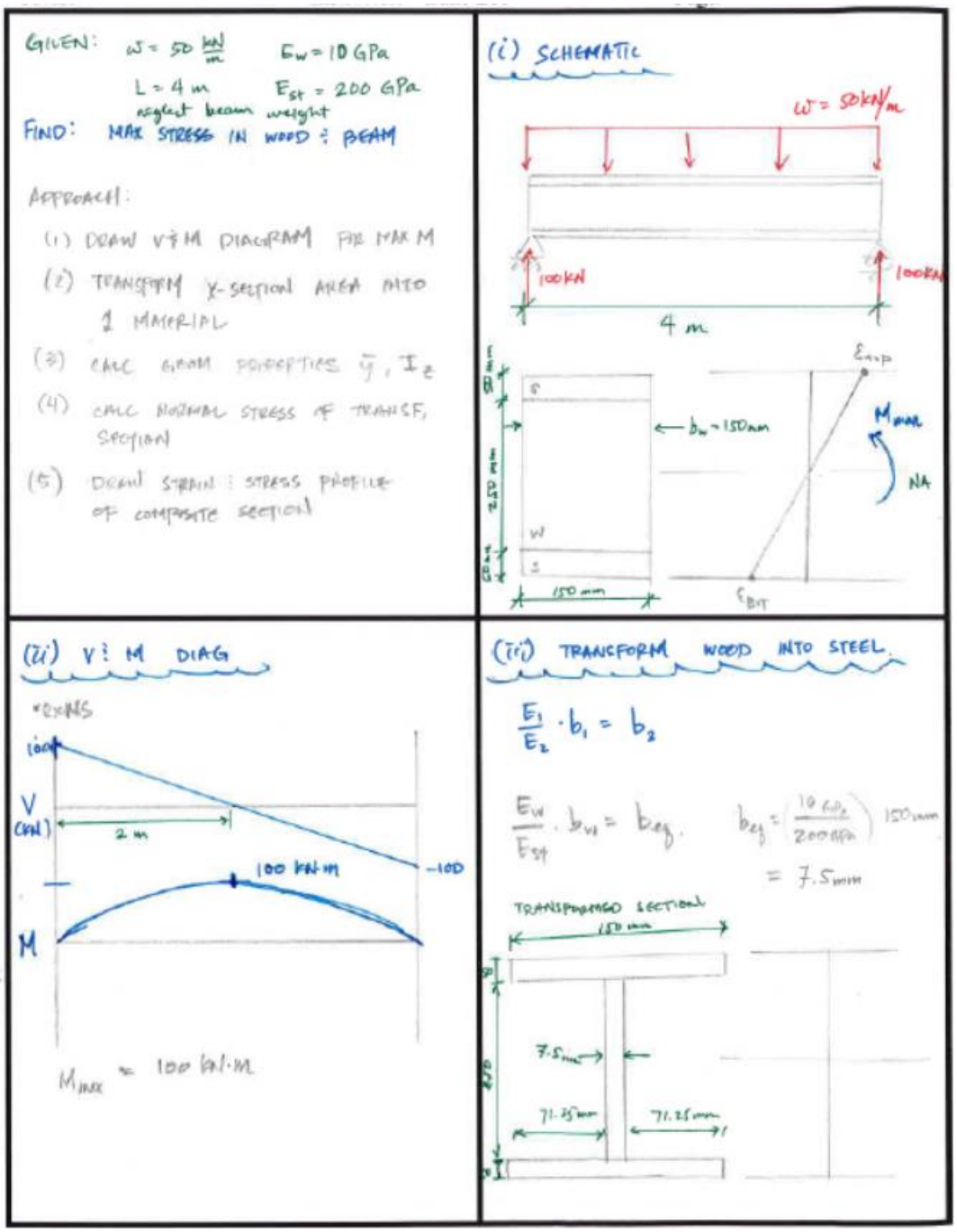

Figure 4. Board Notes Example

The following hardware and software components can be used by authors to create screencast tutorials:

- Tablet PC - Microsoft Surface Pro 3 and Lenovo Yoga ThinkPad
- Microphones - Blue Yeti, Koss CS 95 Headset
- Screen Capture and Editing Software - Camtasia Studio

- Writing Software – Windows Journal, Microsoft Office OneNote

Use Voice to Connect with the Viewer

A video at its best can stimulate the sight and sound senses of the audience to elicit an emotional response; consequently, the spoken voice on the video best characterizes the instructor's presence and is the best opportunity to engage and to motivate the viewer excitement. An effective use of voice is to elicit and maintain attention and to stimulate the viewers emotions [13]. Lowman [13] provides many exercises for instructors to improve communication skills through their speaking voice. While the expressive range of professional actors is not necessary to make an effective and engaging video tutorial, the following recommendations or practices may be useful in increasing audience retention through the length of the video:

- Use variations in pitch, inflection, and pace to engage and to retain attention [13]. Simple variations in pitch and changes in pace can convey enthusiasm for the topic or be used to highlight critical steps in a video tutorial. It is worth noting that voice projection is not as essential in video production as it is in the classroom environment, since audio volume can be adjusted during the post-production process.

- Record the video as if it were a one-to-one tutoring session. Often instructors are more comfortable in one-to-one instructional environment and can convey a more relaxed energy that can be inviting to the audience [13]. Another consideration is to record the video tutorial during a live office hour session with one or two students, which can help the instructor express energy and enthusiasm in his/her speech, similar to how a live studio audience helps actors perform to the best of their abilities.

Write/Draw Clearly

Many engineering video tutorials involve video screen capture of an instructor solving example problems on notetaking software (e.g. Windows Journal or MS OneNote); therefore, writing and drawing clearly is critical to creating an effective video. An instructor using Board Notes should aim to have the text and images identically reproduced on the notetaking software during the tutorial.

At a minimum the text should be large enough to read, since videos may be viewed on mobile devices with smaller screens. Often it is much easier to have neater writing when writing in capital letters. In the authors' experience, writing letters at least 1/8" tall on PC tablets, when recording at a video resolution of 720p, tends to be visually accessible when uploaded on YouTube and viewed on mobile devices.

Drawing software also makes it easier to integrate multiple colors into the handwriting and diagrams. Colors can be useful in creating a more visually stimulating presentation or can be used to distinguish between features in a video (e.g., problem statement – green, headings in problem solving steps – blue, boxing final answers – red, etc.)

Stage 3: Post Production

Edit to be Concise

While editing was not identified directly as a critical feature for engineering video tutorials by students and instructors, concise (part of organization in Q2) presentation can be achieved by properly editing the video. That is, editing in post-production is an effective means to creating short, concise videos. A well-edited video can cut and blend segments together to maintain the flow of the video and keep the viewer engaged in the learning process. The following recommendations in the editing process can help shorten the duration of a video tutorial and help create a video that keeps the viewer engaged:

- Cut out verbal tics such as deep breaths, sighs, grunts, and phrases (e.g. "you know", "so", "okay", etc.). The excessive occurrence of verbal tics in an instructor's speaking voice can distract from the ideas being presented [13].

- Cut or speed up portions of videos where there is silence due to the instructor writing out text, equations, or drawing figures. This keeps the instructors voice active throughout the entire length of the video and minimizes periods of silence where the attention of the viewer can be lost. For instance, in video editing software the clip speed can be increased to transition quickly through time where only writing or drawing occurs in the video.

CONCLUSIONS

In this paper, survey responses to questions on engineering video tutorials were presented to examine the use and desired characteristics of videos in engineering education. Survey results suggested that engineering students are most likely to utilize online engineering video tutorials for homework help and support for test preparation. The primary goal of the survey was to identify the qualities and characteristics that constitute a quality engineering video tutorial from the perspective of students and instructors; the major findings from the survey are summarized as follows:

- For both students and instructors, approximately 40% of responses were classified under the category of Organization, where desirable videos were able to (1) convey information succinctly; (2) easy to comprehend; and (3) arranged in a systematic manner (i.e. step-by-step).

- Responses categorized under Content was the second most common response when combining students and instructors, with students favoring "examples" or "problem solving" type videos; whereas, instructors appeared more focused on maintaining the viewer's attention with "interesting" and "interactive" videos.

- The focus on audience retention was evident in instructor responses with the Instructor Presence category having approximately the same number of responses as the Content category amongst instructors surveyed.

A second goal of the paper was to provide recommendations to create engineering video tutorials that align with the desired qualities and attributes as expressed by engineering students and instructors. The recommendations provided in this paper are summarized below:

I. Pre-Production

a. Define one learning objective for the video tutorial
b. Create board notes as a storyboard before recording

II. Recording

a. Use necessary hardware and software to make the video accessible
b. Use Voice to Connect with the Viewer
c. Write and Draw Clearly.

III. Post-Production

a. Edit to be Concise

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