Leveraging Internet Marketing Technologies and Green-Screen Techniques for Developing Engaging STEM and Online Content

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Abstract

The paper presents tools, approaches and preliminary results for online content creation of Science, Technology, Engineering and Mathematics (STEM) topics to capture student attention. CTU Engineering Department investigated software from the internet marketing niche in support of creating multimedia content for the online course delivery of 'Introduction to Engineering' in 2016. The engineering faculty created a YouTube channel to serve its video content. The content supports a flipped classroom approach as defined by the department from a totally online delivery of instruction. Preliminary results show student satisfaction with this teaching pedagogy. Ongoing improvements include investigating software tools and green-screen techniques to increase student engagement. For example, interactive video learning techniques with embedded 'hot links' within a video can promote student attentiveness. The teaching innovation allows students to have options or call-to-actions such as: watching more videos, perusing other forms of content, or taking a short quiz or other assessment activity.

Keywords

online flipped classroom, internet marketing technologies, e-learning, multimedia, green-screen techniques

Introduction

Colorado Technical University (CTU), a subsidiary of Career Education Corporation (CEC), has students consisting mostly of adult learners who are working full-time. CTU successfully developed and implemented a program curriculum consisting of day and night classes in electrical and computer engineering to accommodate the working adult. With day and evening engineering courses being 11 weeks in length, the curriculum and flexible program schedule allows students to successfully complete an ABET-accredited degree in either BSEE or BSCE. Engineering courses for obtaining an MSEE and MSCE degree are only offered in the evening.

CEC made strategic plans during 2015 to provide online delivery of undergraduate and graduate engineering courses. In response, CTU developed a long-range plan to deliver several engineering courses online. The engineering faculty decided to first develop a course entitled, Introduction to Engineering. The department adopted a flipped classroom approach for online content delivery described and defined in more detail later in this paper as well as describing how content was generated. The department started the planning of online content in April 2015.

Gaining Experience for Online Delivery of Engineering Content and Adaptive Learning

CTU has four full-time engineering faculty at the Colorado Springs campus and are newcomers in developing online engineering courses. Because the engineering faculty has its primary focus on teaching, the full-time instructor carries a typical workload of four courses/per quarter. Consequently, each instructor has taught between thirty to forty different engineering courses, including math and physics during their stretch at CTU. However, with this recent online initiative, the instructors have been downloaded to 2-3 classes for one year to focus on content creation and instructional delivery.

To gain experience in developing and delivering online courses, four instructors (which includes the Engineering Department Chair and the authors) were all involved in creating content for a freshman-level course, Introduction to Engineering, during the Summer Quarter and Fall Quarter of 2015. Professor Guo was the lead professor integrating the content from other instructors. The planned rollout of the first course was intended to refine the content during these three quarters before delivering the polished version of the first course fully online in 2016.

During this development cycle, the department created a YouTube channel entitled, 'STEM Videos for the Flipped Classroom' and gained valuable skills and insights when creating and testing the content for online delivery. Figure 1 is a screenshot of the department's channel.

Figure 1. STEM Videos for the Flipped Classroom

The engineering content supports the flipped classroom philosophy defined by CTU and requires integrating it with CEC's learning management system (LMS) and its adaptive learning (AL) software[1] at Chicago. Throughout this development, the integration effort required frequent coordination to ensure a rewarding learning experience for the student. Results of CEC's AL software with trigonometry and pre-calculus courses for the blended learning model appeared in the 2016 ASEE Conference[1]. The engineering department intends to use the AL software to provide more practice in solving problems by automating and generating random homework problems for future development of engineering courses. For example, random values of circuit components in various network configurations are generated for each student. Here, students can solve a variety of circuit analysis problems that are different and not repeated for each student using different solution methods. After gaining some experience in generating and refining the online course content, feedback in regards to the content delivered in a pilot course is discussed next.

Feedback from Pilot Study of 'Introduction to Engineering' and Follow-up Activities

During the 2016 Winter Quarter, CTU held a Pilot Focus meeting that served as an end-of-course feedback in March. Face-to-face student group interviews about the effectiveness of the piloted course was discussed. The course instructor, Professor Guo, was not present during the group

interview in order to promote more honest feedback and a less threatening environment. The interview was conducted by the College of Engineering Dean and Engineering Department Chair. Table 1 are meeting notes summarizing the results from student comments. In general, the overall content and instructional delivery was well received. The content was further refined and developed during the quarter correcting minor errors identified by student feedback. Four students were able to make the focus group meeting when usually 7-8 students out of 11 are in attendance during class.

STUDENT COMMENTS, WINTER 2016
1. Student consensus that errors were few but one student found it distracting
2. *myDAQ-based equipment is very effective for the lab experiments.* There were some issues dealing with insufficient drive current from the internal power supply in myDAQ. There is further need for an external multi-meter to complement the internal one so that voltage and current may be measured simultaneously. One student noted that a distracting lag between his commanding a function and the realization of that command.
3. *Videos and slide sets are well done and useful. There is a good balance between paper and online content.*
4. *The problem assignments were well done and useful*
5. One student said that the course is very intense. Snow days should not be allowed. You fall behind.
6. *They wondered if online labs would be effective as those in class live and in person. There is a lot of person-to-person interaction in solving problems with the labs. The department chair noted if students attempt the labs ahead of time and bring their issues to the chats, it should work well.*
7. In response to one of the question as to whether they believed there might be a bias in industry against engineers who obtained their degrees online, the students opined that there should not be but probably is. But they also said they are not yet engineers, do not work in those circles, and therefore do not know.

Table 1. Notes Summarizing Student Feedback On The Piloted Course, Introduction to Engineering

Several months before the focus meeting, one adjunct professor who taught the introductory course (Fall 2015) and quality-checked the course material reinforced comment 3 of Table 1. The adjunct approached Professor Santiago saying that student feedback on the videos and course content were very good and much appreciated by the students.

Due to workload and resource constraints, CEC decided to change its strategy and implement its near-term plan to deliver the graduate engineering programs online since they are relatively easier and have fewer courses to develop than the undergraduate ones.

Although the undergraduate plans were temporarily placed “on hold”, the Engineering Department wanted to leverage the success thus far from the piloted program. The full-time faculty are continuing to investigate and refine its online delivery methods as well as producing engaging content for future courses. For example, Professor Guo while teaching a second course in circuit analysis, is modifying the existing labs for the myDAQ hardware in preparation for the next round of content development. Professor Santiago is looking at approaches in using PowerPoint as an adaptive learning tool using hyperlinks and Office Mix described in the latter part of the paper. The paper will also elaborate on comments 3 and 6 explaining the engineering department’s teaching philosophy and explaining how content was generated. However, the ongoing challenge remains to carry on translating the face-to-face teaching style and active learning approach and making it suitable for online delivery of engineering courses. Professor Santiago’s had early experience with developing multimedia content suited for online instruction. His past experience which eventually led to implementation of the flipped classroom approach from an online perspective is described next.

Leveraging Past Experience to Implement Flipped Classroom Approach

Before CEC presented its 2015 strategic plan to deliver engineering courses online in 2016, Professor Santiago's initial interest was already focused on developing and experimenting with interactive and multimedia textbooks (or e-books) back in 2003, shortly after his retirement from the U.S. Air Force that same year. Ideally, he investigated on developing multimedia textbooks consisting of videos and other media mixed with recordings about using engineering tools and interactive teaching platforms like Matlab/Simulink, Labview/Multisim, PhET and Algodoo. He investigated a number of internet marketing technologies that appear applicable for developing educational content and suited for online delivery. His research efforts led to uploading of experimental YouTube videos in 2008. His educational and creative efforts on YouTube led to a published book[2] in 2013 described later in the paper. Professor's Santiago experience in content generation with multimedia e-books is also discussed later sections. His past experience guided the engineering faculty for online delivery.

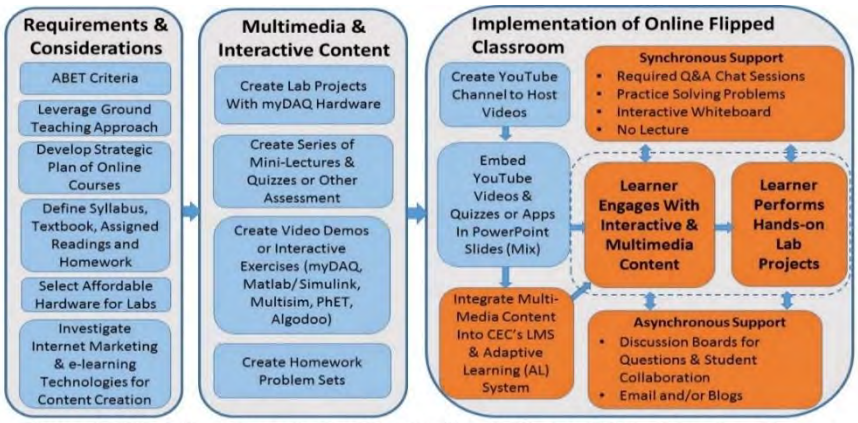

Figure 2. Workflow Description For Online Delivery Of Engineering Courses

Leveraging Professor Santiago's knowledge and feedback from engineering instructors, Figure 2 provides requirements and considerations for delivering online engineering content. Figure 2 also shows flow of multimedia content and overview of implementing the online flipped classroom approach. Before describing the detailed implementation of the flipped classroom, the next section describes the traditional face-to-face teaching philosophy to form the department's online teaching philosophy.

Traditional Face-to-Face (Ground) Teaching Philosophy

Typical engineering courses taught at the CTU Colorado Springs campus are two to three hours long meeting twice a week. The teaching pedagogy uses a student-centered approach where they take active participation in their learning as opposed to passive one-hour instructor lectures in class. For example, one approach of instruction involving engineering problems a number of analytical concepts, such as circuit analysis or signals and systems involves the following steps:

- Step 1. Introduce and present a topic for 5 minutes. Motivate why this topic is important and relevant to the course keeping it short and sweet. Also show how information will benefit them or tell a relevant war story based on industry experience.
- Step 2. Solve an example engineering and analytical problem. This usually takes 5 to 15 minutes depending on the complexity of the problem
- Step 3. Have students struggle with another similar problem for 10-15 minutes.

- Step 4. Solve problem together – 10-15 minutes. An instructor can have one of the students solve the problem on the whiteboard and appropriately guide the student to unravel the problem requesting feedback from other students as well.
- Step 5. Break (5-15 minutes)
- Step 6. Repeat process for the next hour

The above approach is not set in stone so that an instructor can adapt delivery of the material according to any student questions and needs. For the following hour, an instructor may have a short lab or hands-on exercise using Matlab/Simulink or PSPICE to reinforce the concept taught during the first hour. The above pedagogy is consistent with past teaching philosophies.[3,4]

After this explanation of the traditional face-to-face teaching, the flipped classroom approach is described next from an online perspective.

Detailed Description and Implementation of the Online Flipped Classroom Approach

When students first heard of CTU's preliminary offering of delivering engineering courses online, most of their immediate responses goes something like this: "there is no way I'm going to take an engineering course online". But after explaining the online and flipped classroom approach described below, most of their fears and concerns appear to subside and were less adamant on their position. As expected, some students remain skeptical since learning engineering is a challenge in a traditional classroom and face-to-face setting learning environment.

For online delivery, the overall goal is to develop effective teaching innovations and timely help students efficiently learn topics in STEM. One teaching approach consists of translating and transforming the teaching delivery taught in the traditional face-to-face classroom to one apt for online delivery of the course material. In other words, how can the engineering faculty leverage and use current e-learning technologies to implement and transform the face-to-face teaching style suitable for online instruction.

In Figure 2, the block labeled 'Requirements and Considerations' highlights and summarizes some of the key points in the earlier sections. Also, the next two blocks of Figure 2, labeled as 'Multimedia and Interactive Content' and 'Implementation of Online Flipped Classroom', are discussed next. The online delivery will use a flipped classroom approach as defined by the following three main concepts as depicted in Figure 2.

The first concept is to develop engaging and interactive multimedia content. This includes gaming techniques in the future as incentives after initial development of multimedia content. The initial phase consists of developing videos, assigned readings/homework and laboratory experiments.

The set of videos will provide a technical foundation made up of a series of short mini-lectures (usually lasting between 5 to 10 minutes for each video) followed appropriately with a series of short assessments to verify and validate student understanding. Students must view the interactive content outside the classroom while addressing the call-to-action or assignments from the video. These actions must be completed before the online chat session.

In a traditional classroom, the content would be delivered as lecture material. The instructor must reflect on what and how the face-to-face instruction was conducted and determined if it can be implemented for online delivery by leveraging available e-learning technologies. The videos should also include demonstrations or simulations by visualizing and applying the abstract math and engineering ideas to real-world problems. Video recordings on the use of engineering tools such as Matlab/Simulink, Labview/Multisim, PhET and Algodoo software, can serve as examples to demonstrate key concepts found in a particular course and developed for this first course. The video instruction can also include demonstrations of real-world applications. For example, in the capstone design courses and projects, students can use relatively inexpensive microcontrollers such as Arduino, Raspberry PI, and Beaglebone to serve as complementary hardware with the myDAQ from National Instruments. These affordable microcontrollers have been investigated or used by past student group projects. Instructors can also use myDAQ and the microcontrollers to demonstrate key concepts found in circuit analysis and electronics courses. To further promote user engagement, any student questions raised from the interactive and multimedia content can be addressed in the online and required interactive chat sessions.

From an online perspective, synchronous delivery means classroom time when the instructor and students are online together (commonly known as a chat or synchronous session). The conduct of the required Q&A chat sessions are discussed next.

The second concept involves minimal or no lecture material presented during the online sessions when students and instructor meet synchronously on a weekly basis. The engineering department determined that there is very little time to provide a thorough lecture-based material during online sessions. This concept allows more student engagement as a follow-up to the multimedia content presented during the week. The chat sessions are recorded. If students are unable to attend the chat session, then they must view the recording and turn in an assigned project or solve a particular homework problem before the chat session. These sessions should be reserved for addressing student questions based on the weekly online multimedia content, required readings or hands-on laboratory experiments or simulation exercise. The primary intent of the chat session is to provide more practice in showing students how to solve more problems while addressing student questions.

Before the chat session, the instructor can set up a discussion board where students can submit their questions. Other students can answer these questions as well and earn points toward a leaderboard providing incentives such as reducing the number of assignments that they need to do or earning extra credit points. The chat sessions are primarily student-centered activities based on problem-solving exercises/projects where most of the time is answering student questions. The primary goal during the chat session is to facilitate and save time for students in solving problems by showing more examples of worked-out problems of assigned homework. Questions on the use of engineering tools described earlier can be addressed here as well.

The synchronous chat sessions will also include an interactive whiteboard between the students and instructor. For example, a chat session may involve an instructor who completed step 1 in solving an assigned homework problem on the whiteboard. The instructor can then canvas the audience or select a student by asking: what's the next step toward solving the problem? In addition, homework problems during weekly chat sessions, students may ask questions for assigned lab or hands-on activities for that week. If a self-motivated student does not need to

attend the chat session and has successfully completed assigned homework before the chat session, then the student gets credit or is excused from attending the session.

The final concept consists of hands-on projects to verify and validate the student understanding of concepts, analysis, design and building of their proposed solutions. Students need to do projects or lab experiments that are either a software simulation such as Matlab or laboratory experiment using myDAQ hardware with supporting instrumentation software as part of the course. CTU adopted National Instrument's myDAQ as a learning tool to provide the hands-on experience in several engineering courses, including the 'Introduction to Engineering' which worked well based on student comments. Discussion boards can be used for students to collaborate on lab experiments and to address comment 6 of Table 1. Students should have the ability to start chat sessions among themselves with the Learning Management System to document their collaboration. In place of a written lab or research report for selected projects or lab experiments, each student is tasked to record a 5-to-10 minute video on selected projects or lab experiments whether performed in a group or individual setting. Chat sessions can be used to address student questions on the labs as well. Students can submit their lab questions on another discussion board the day before the chat session takes place. The instructor can use the information to prepare the chat session. Further details about applying this online flip classroom for 'Introduction to Engineering' can be found in another paper[5].

On a precautionary note, using the online flipped classroom approach, students are viewing videos and reading course content on their own time outside the chat sessions. Consequently, the instructor needs to be careful of the student workload when assigning homework. The intention of the synchronous chat sessions, is to perform several worked-out homework problems and address student questions about the assigned homework, laboratory experiment or other student-centered activities and questions arising from the multimedia content.

As depicted in Figure 2, the results of CTU's online flipped classroom philosophy uses a combination of synchronous chat sessions and asynchronous tools (discussion boards and emails). Synchronous chat sessions offer self-motivated learners who need more faculty interaction. For those who are unable to attend the synchronous chat sessions, the asynchronous approaches are available for self-motivated students and time-constrained with the realities of daily life[6,7]. Although the online content was tested through a piloted course with ground (or face-to-face) students, the online teaching pedagogy appears to be reasonable and promising, based on comments 2 through 4 of Table 1. Student feedback from comment 6 about online delivery of myDAQ labs is described in more detail by the authors in another paper[8]. CTU's online teaching philosophy and implementation will continue to evolve as the engineering faculty gains more experience in delivering courses online.

For CTU engineering faculty, the major considerations and lessons learned when integrating the three concepts are that it's very resource intensive, namely:

- Requires extensive time to build quality interactive and multimedia content
- Requires learning new skills to produce engaging videos or multimedia content
- Variety of video types and more engaging videos may be necessary requiring use of green-screen techniques, character animation, gaming techniques, kinetic text and whiteboard video in motivating students for a four-to-five year engineering program

- Requires learning new software such as Camtasia for video screen capture and video editing
- May require learning other content creation tools such as Adobe Products (Photoshop, After Effects, Illustrator, Premier, etc.) for visually appealing content
- Requires a dedicated team with appropriate skill sets to produce quality and engaging online content and instruction.

The engineering department intends to find more efficient ways when developing the course material. For example, if time is an issue in developing video content, then a team of instructors could spend their time researching, leveraging and curating other videos found on YouTube. However, some of the top engineering schools, have posted some of their traditional 45-minute or one hour lectures on YouTube, so viewing these videos will take time for both instructors and students. The CTU engineering department chose to develop their own content to suit its online needs of instruction for a particular course and when appropriate, leverage videos uploaded on YouTube or other video content providers. Since some portions of an hour-long YouTube video may not be relevant for the course, then it would be helpful to have video players to start and stop at the appropriate place.

Because studying engineering is very challenging for most students, especially when learning the technical content online, the delivery of the course needs to reward self-motivated students with quality content and instruction to keep students engaged in the learning process throughout the engineering program. Taking a long-term strategic view, eventually all engineering courses will be delivered online while ground campuses are for those in the local community who prefer some face-to-face instruction.

In summary, the full-time engineering faculty gained valuable experience in developing content appropriate for online delivery for the first course. The next section describes past experiences on developing and generating the course content. Links to YouTube videos created by the engineering faculty with hyperlinked text or images serve as examples in an attempt to provide a more interactive learning experience for the student. Some videos by Professor Santiago were created leveraging software coming from the internet marketing niche and combined with green-screen techniques. Due to space limitations, only selected internet marketing tools and video creation techniques (e.g. Camtasia) are highlighted as examples based on the department's experience. Relevant and past experiments are summarized about developing engaging content as well as a number of teaching innovations that was experienced during the last several years.

Create Interactive Content Using Camtasia and YouTube plus YouTube's Analytic Engine

Professor Santiago's initial and continuing interest is the creation of interactive and multimedia e-books which served the department well in developing the course, Introduction to Engineering. He found software that converted a website having multimedia content into a standalone e-book. However, he quickly discovered that creating the multimedia content takes more time than he anticipated and that the file size of an e-book is very large to download or email during that time. However, with the birth of YouTube and the use of its embedding video feature, the file size of the e-book can be significantly reduced. For example, one set of videos for 'Introduction to Engineering' had a file size of 112 Mb for a particular learning module…too large to be sent to IT personnel at Chicago as an email attachment. Uploading the videos on YouTube and

embedding them within PowerPoint slide resulted in a file size of 1.2 MB. Using this technique results in about a 93-fold file size reduction which is small enough to email as an attachment. The embedded video technique can be adapted to provide personalized instruction for those students who request help through email.

Professor Santiago's educational efforts on YouTube also led to publishing a reference book in circuit analysis[2]. During 2012, a literary agent contacted him after the agent researched and discovered Professor Santiago's YouTube videos leading to publishing his book in April 2013. Future plans include producing a similar book having multimedia or a video-centric companion website. Based on this experience, course exercises could include students to upload YouTube videos about their laboratory experiments or capstone project. These videos can be used later as part of their electronic portfolio as they complete their engineering program.

Professor Santiago also investigated on the use of Adobe Acrobat. Unfortunately, he discovered Adobe pdf books currently do not allow embedded YouTube videos. Although, there is some third-party widget software that allows the integration, it requires more technical expertise to integrate the YouTube videos into pdf formatted books but is not particularly visually pleasing and user friendly when integration is completed. However, there is third party software, which converts a pdf into a digital flipbook that allows an instructor to insert online videos from either YouTube or Vimeo. Professor Santiago experimented only with the text-based version which functioned well online and is visually pleasing. Links to YouTube or other video websites can be inserted into the text-based flipbook since the digital flipbook that features embedded YouTube or Vimeo videos is more expensive. The multimedia digital flipbook with embedded online videos will be investigated and tested in the future which appears to be promising.

After acquiring some skills to develop an interactive website back in 2003-2004, Professor Santiago began researching multimedia creation tools from the internet marketing niche. Professor Santiago learned that entrepreneurs who are using videos to promote internet marketing or other affiliate products have been using Camtasia produced by TechSmith. The tool became one of the first and must-have video creation and video editing tool for Professor Santiago. For those who are not familiar with Camtasia, it's basically both a video screen capture and video editing software that has many features to promote viewer engagement. Recently, other popular video editing software began incorporating this screen capture feature as well. However, Camtasia was originally targeted for the educational marketplace and evolved from being a program for software demonstrations back in 2005 to a full-featured educational tool in 2015. Despite the large number of current features, its learning curve is manageable based on faculty use of Camtasia. Table 2 lists key educational benefits & features of Camtasia, appropriate for keeping the learner attentive and establishing an interactive dialog with video. Performing screen capture with Camtasia has the advantage of requiring a relatively small initial capital investment and logistics when compared to a video recording studio.

Using keyword search tools from Google, Professor Santiago found that circuit analysis was frequently queried and there were few pages and video content (if any) on this subject at that time. He then experimented and developed videos in support of a first course in circuit analysis and a first course in differential equations (which is a prerequisite for a second course in circuit analysis involving ac circuits with capacitors and inductors).

Interestingly, Professor Santiago discovered that the recorded videos covering key concepts required approximately ten hours of recorded videos for each course. Based on this information and for analytically-based courses, about one hour of video recordings are needed each week to cover key concepts for the 11-week course. This makes sense and is consistent with CTU's engineering face-to-face teaching philosophy. In other words, most of the face-to-face time in a traditional ground classroom setting is spent doing more practice in solving problems or hands-on lab activities. This led to the idea for online chat sessions dedicated to addressing student

Camtasia Feature	Description	Educational Benefit
a	Hot Spots	Students can choose a particular learning path and interact with video by clicking on buttons or characters. Create attractive PowerPoint slides and import with Camtasia. Allows anything to be clickable so learner can move seamlessly to a new screen or even outside the video to additional learning materials.
b	Add-in to PowerPoint	Screen Capture of PowerPoint Presentation delivered in a micro-learning fashion and combined with cursor highlighter to keep learner attentive.
c	Ability to Collect and Report Test Scores	Create Quiz and Collect Results via email. Organizes them and sends a daily report of how students are doing,
d	Multiple video Windows or Tracks	Keep Learners attentive. Display screen recording inside one window, presenter talking in another and an animation to go along with the screen recording in the third.
e	Green-screen removal	Overlay videos to create interesting learning scenarios. Need to avoid too many moving parts that will distract the learner
f	Call-outs	Can be used to call attention to the learner on a key concept or call-to-action. Like calling attention to the learner on an area on the video
g	Cursor highlighter	Can be used to keep interest to follow the animation of a hand-written sketch or text similarly found in a whiteboard presentation...has potential for a Dopamine effect.
h	Pan and Zoom	Use to highlight an area of interest in the screen and to create variety in what's being displayed and keep learner attentive
i	Markers	Use to create a table of contents of portions of a long video

Table 2. List of Key Features in Camtasia & Educational Use

questions based on viewing videos, reading text material, doing lab experiments, and solving homework problems. Moderating the online discussion boards will also supplement the chat session approach to promote more student engagement. In terms of video content, it took only about 8.5 hours of recorded video lectures for 'Introduction to Engineering' course having numerous engineering lab activities than circuit analysis. So about 46 minutes of video content per week are needed for the 'Introduction to Engineering' course that is primarily laboratory based. Based on the experience of Professor Guo to teaching the laboratory content, she believes that more videos may be needed to provide additional help for students[8]. For online delivery, a problematic issue is helping students troubleshoot their circuits[8]. Hangouts, Skype or video chat sessions with either the instructors or with other students are possible solutions. Another means is the development of a troubleshooting checklist that students need to follow before requesting help from the instructor.

Professor Santiago introduced and taught the basic use of Camtasia to the CTU Engineering Department and made full-time faculty aware of advanced features to keep the learner attentive as they investigate its Camtasia's features while developing the content for the course 'Introduction to Engineering'.

Table 3 provides a high-level analytics summary of selected and experimental YouTube Channels. Experimental Channels 1 and 2 are personal channels of Professor Santiago and Channel 3 was created for the CTU engineering department (STEM Videos for the Flipped Classroom). In general, more videos with engaging content, results in more subscribers. Also, it takes time to build a subscriber list. Channel 3 was created during March 2015, but initial

postings of video content for the piloted program began in July 2015. CTU completed the final uploading of videos in March 2016 for the introductory course. Additional related and improved videos were posted afterwards.

The number of subscribers, likes, and dislikes can be used as a preliminary measure of engagement although more studies of other metrics (e.g. ratio of likes/dislikes, average viewer time, ratio of average viewer time/total time, etc.) need further investigation. However, the first and primary effort is the development of multimedia content and the process for online delivery. Data analytics provided by YouTube will be examined in the future to gain more insight about the metrics to improve the student learning experience.

Channel	Number of Views	Subscribers	Number of Videos	Channel Created on:
Channel 1: Variety of EE Topics (includes DC Circuit Analysis as well)	3,369,160	7460	160	January 19, 2008
Channel 2: Primary focus is on Circuits analysis	882, 403	2700	50	February 21, 2009
Channel 3: Introduction to Engineering and other topics	9,716	35	103 (77 videos for Introduction to Engineering)	March 25, 2015

Table 3. High-Level Summary of YouTube Videos on Engineering Content

Table 4 lists samples from the engineering department from the four instructors. Since most of the instructors are new to making videos online and using Camtasia, some of its useful software and e-learning tools may not have been used to create more engaging videos. However, the piloted students still felt that there was a right mix of videos and text based on comment 3 of Table 1. Future videos will incorporate the advance features of Camtasia with Professor Santiago providing advice to other instructors on how to effectively use Camtasia's advanced features. Although there are some videos using PowerPoint, a majority of the videos in Channels 1 and 2 are based on recordings of writing on a laptop tablet. These recordings can be viewed as

Instructor	Topic	YouTube Link
Jing Guo	Circuit Simplification Digital Circuit Simplification	https://www.youtube.com/watch?v=HuVVZOdJNyY https://www.youtube.com/watch?v=dKLfukkK2zw
Pamela Hoffman	Digital Circuits	https://www.youtube.com/watch?v=YLE-IUDSM_A
Kathy Kasley	IC Manufacturing General Number Representation	https://www.youtube.com/watch?v=5DOrRS8jsoo https://www.youtube.com/watch?v=XpATuhF7zPE
John Santiago	Summary of Circuit Analysis Animation Humor – Crazy Scientist	https://www.youtube.com/watch?v=3DoOQbYPAa0 https://www.youtube.com/watch?v=BGp2fNRLIxo

Table 4. Sample and Initial Videos from CTU's Engineering Faculty

whiteboard or scribed videos which are popular and uploaded to YouTube during 2008. Videos in Channel 3 are done mostly in PowerPoint. Professor Santiago's content consists of embedded YouTube videos and a mix of recorded PhET simulations, MATLAB/Simulink demonstrations, Algodoo and live videos. Some of the videos use green-screen techniques and kinetic text. There are also character animations found in Channels 1 and 2 as well at the IEEE CTU Student Branch Website.

In addition, the next section explains some scientific and psychological explanation on why whiteboard or scribe videos which is like doodling disguised as deep thinking are effective for instruction[9,10]. Results of sample whiteboard videos in YouTube are also described in the next section.

Whiteboard (or Scribe) Videos and the Dopamine Effect

Smy's[9] video blog shows Wiseman's research explaining how scribe or whiteboard videos gain and hold attention as well as preliminary data shown back in Table 4. Table 5 shows the results from some of Professor Santiago's popular videos. Whiteboard videos put people in a better mood rather than having the audience view a PowerPoint presentation reading all that text.

The reason why whiteboard videos are effective is based on the Dopamine effect mentioned and explained by Richard Wiseman in Smy's blog article[9]. That is, whiteboard videos stimulate viewer anticipation. It's like a crowd gathering around a street artist to figure out what is being drawn. Watching the image in a scribe video begin to emerge stimulates the brain. As the sketch is being drawn, the brain anticipates its final form. When the final form is exposed, the brain experiences a surprise releasing Dopamine. A sudden chemical release of Dopamine allows the viewer to experience pleasure which in turn increases engagement of the viewer.

Video Title/Link	Date Uploaded	Number of Views	Likes	Dislikes
1. Signal Processing Tutorial: Discrete-Time Convolution Examples (Inverse z-Transform) https://www.youtube.com/watch?v=yzV3xW8YfzQ	20 Apr 2008	28,905	60	1
2. Matlab Examples - Review of Discrete Convolution using Matlab https://www.youtube.com/watch?v=bPAKMS6_FWg	27 Apr 2009	39,039	61	4
3. Matlab Tutorial - Amplitude Modulation https://www.youtube.com/watch?v=rH-EtQB8tPc	25 Jun 2008	108,844	146	13
4. Operational Amplifier Tutorial – Basic Op Amp (Part) https://www.youtube.com/watch?v=5GR8M5h-5H0	1 Mar 2009	246,143	511	24
5. Simulink / Matlab Video Tutorial and Example - Low Pass Filter - Bode Plots (Part 2) https://www.youtube.com/watch?v=Ehb0E_j0bMk	3 Jul 2009	202,657	181	8
6. Thevenin & Norton Examples - Tutorial on Thevenin Equivalent Circuit Theory - Part 1 https://www.youtube.com/watch?v=16MO8vIWuqo	6 Mar 2009	146,018	161	28
7. Electric Current: Define Electric Current Flow With A Water Analogy https://www.youtube.com/watch?v=pcn6CNMJdzI	5 May 2015	4085	13	0

Table 5. Sample Videos Using Camtasia

For engineering topics, the whiteboard video if done and delivered correctly will offer students an opportunity to experience an 'aha' moment when solving a problem as they proceed through the video. The whiteboard video essentially provides a near face-to-face experience simulating a face-to-face instruction. It's as if the student has an over-the-shoulder professor guiding a complex problem throughout the process. Table 5 lists sample videos of whiteboard and PowerPoint presentations using animations as well as recordings based on Matlab/Simulink, PhET and Algodoo simulations.

The whiteboard videos can lose its Dopamine effect as with any teaching mode of delivery when the element of surprise or anticipation is diminished. So judicious use of the whiteboard video should be considered. That's why other video types or other multimedia content should be mixed in with whiteboard type videos when delivering the content throughout the course. For example, in a face-to-face classroom setting, the instructor can use PowerPoint to save time in drawing figures and explain concepts during class, then use either Matlab/Simulink demos or a whiteboard to either emphasize a concept or address a student question. This diverse instruction for the face-to-face student can be translated to mixing content types, various video types, and different interactive assessment tools to help online students become more engage in learning.

Today, there are internet marketing and affordable software allowing the educator to create professional-looking whiteboard sketch videos within minutes. Today's software allows the educator to use green-screen techniques mixing video backgrounds in high-definition, kinetic text, 2D/3D cartoon animations and whiteboard sketches. The educator can combine these elements and styles creating a variety of videos. The time-of-investment in doing so is still unclear when compared with the easy screen capture of whiteboard videos. However, providing an original mix of video types will create variety so that the student does not experience the same mode of instruction repeatedly. Variety of appealing video types offers an element of surprise and viewer anticipation. Examples of types of videos with variety (some) that are interactive ones can be found on the following links on YouTube: (1) Video 1 show results, that combines green-screen techniques and video creation tools from the internet marketing niche using Camtasia. During the video is an interactive quiz with an 'i-icon' found in the upper right-hand corner with over 40 viewers taking the quiz. (2) Video 2 (Interactive Video Learning) shows sample video with a concluding section (or outro) with embedded hot links on images of the video to give students options to view other videos. You can also include hotlinks to take a quiz. (3) Teaching Innovations is a link of experimental innovations at IEEE CTU Student Branch Website, such as: digital flipbook, drag and drop assessment, and 2D/3D character animations.

Embedded Videos, Quizzes and Interactive Web Pages in PowerPoint Using Office Mix

Professor Santiago used a series of embedded YouTube videos in PowerPoint along with quizzes to create a seamless delivery of multimedia content without jumping between the YouTube website and PowerPoint application. Figure 3 provides a flowchart as an example of this approach when an online student downloads the PowerPoint slides.

Also, Figure 3 shows a 'Table of Contents" found on slide 2 so students can have an option to select a subset of the 45-slide learning module if portions of the presentation is already familiar or seen earlier by the student. With the latest and recent add-in by Microsoft, called Office Mix, the instructor can also embed the quizzes or review questions in the PowerPoint learning module.

Microsoft developed Office Mix for the education market since most lessons and lectures are delivered by educators using PowerPoint. Office Mix can be viewed as a container to embed external apps within a slide. With Mix, Microsoft wants to fill the gap in building the educational content and how the content is being presented and delivered. In this way, the instructor does not need to jump back-and-forth between PowerPoint and the various apps used in the presentation. Mix can take the PowerPoint slides to create a cloud-based and interactive lessons having built-in tests.

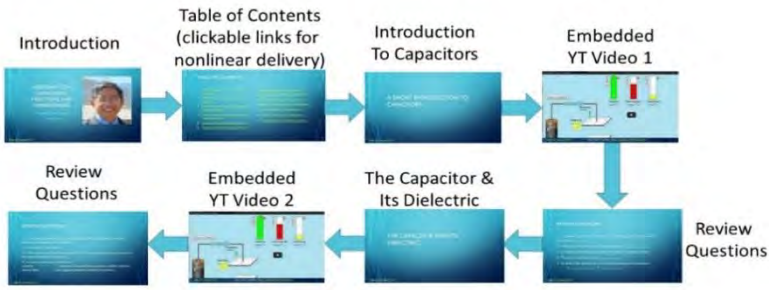

Figure 3. Sample Flowchart of PowerPoint Slides With A Series of Embedded YouTube Videos and Quizzes

Using embedded videos and Office Mix with PowerPoint, offers instructors not only the ability to present their material in engaging ways but to deliver online content through email for those students who need more personalized instruction. Microsoft provided online help for the educator to get started through their gallery on the Mix site containing a series of tutorial Mixes, which can be viewed online, or downloaded and played on a wide range of devices.

After installing the Mix plug-in, the educator will find a new Mix tab in the PowerPoint ribbon. Figure 4 is a screenshot after embedding an application on the slide using the Mix add-in. The figure shows one of the interactive PhET simulation models embedded onto the slide. The authors envision that more apps will be developed that's compatible with the Office Mix add-in. In the future, it may be possible that a cloud-based Matlab/Simulink, Labview or Pspice may be in the works that can communicate with this relatively new add-in.

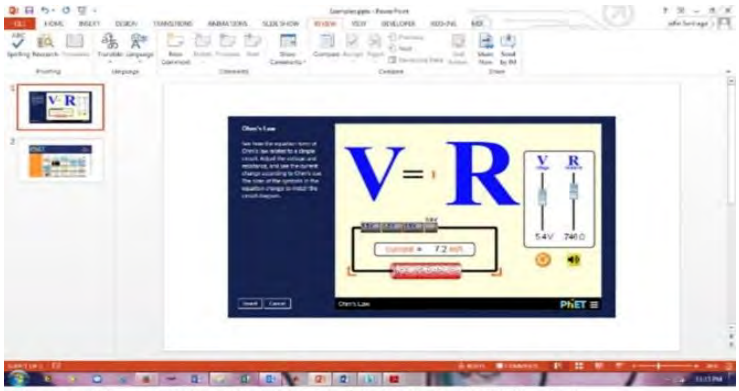

Figure 4. Microsoft Office Mix Add-in Used To Embed A PhET Simulation

Conclusion

CTU's engineering department successfully created engaging multimedia content to deliver an online course, 'Introduction to Engineering' in support on an *Online Flipped Classroom*. Also, preliminary results show the online flipped classroom as defined by CTU has promise once the multimedia content has been integrated into CEC's LMS and adaptive learning (AL) system software. Base on the student feedback during the past year, there was a good mix between online video, text content and lab activities. The full-time faculty gained valuable experience and insights producing multimedia content. The engineering department anticipates the development of future courses will result in shorter timelines as more online courses are implemented in the future. A number of teaching innovations have been presented leveraging technologies coming from the internet marketing niche to create and deliver interactive and

multimedia content. The interactive features of Camtasia, the Microsoft's Office Mix plug-in and the advancement of video players embedded on websites offers opportunities for instructors to rethink their delivery online in creative ways. Although the CTU full-time faculty learned how to develop technical content for online learners, there is still much to learn. The paper and its results attempts to help motivate STEM instructors explore with even more creative ways in delivering their content online. Learning engineering is already a challenge for most self-motivated students. So why not serve and reward them with engaging and interactive content that enriches their learning experience.

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Biographical Information

Professor John Santiago teaches courses in electrical, computer and systems engineering after retiring from the USAF with 26 years of service in 2003. He began teaching at CTU the following year. His interests includes: interactive multimedia for e-books, interactive video learning, and 3D/2D animation. Professor Santiago recently published a book entitled, "Circuit Analysis for Dummies" in 2013 after being discovered on YouTube. Professor Santiago received several teaching awards from the United States Air Force Academy and CTU. Last year, he was awarded CTU's Faculty of the Year for Teaching Innovations. Professor Santiago has been a 12-time invited speaker for celebrating Asian-Pacific American Heritage Month.

Dr. Jing Guo is a Professor in Engineering College at Colorado Technical University. She is the course director in circuits and electronics area. She taught variety of underrated and graduate courses including capstone design in Electrical and Computer Engineering area. She worked as Subject Matter Expert (SME) of "EE110 Introduction to Engineering" Online Course Development.