DEVELOPMENT AND ASSESSMENT OF DIGITAL AUDIOVISUAL YOUTUBE LECTURES FOR AN ENGINEERING COURSE IN NUMERICAL METHODS

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Abstract

Cyberlearning is transforming education by offering course content through multiple context and platforms. As part of this transformation, this paper describes the experience of preparing, recording, uploading, organizing, and assessing audiovisual lectures for an engineering course in Numerical Methods. More than 250 short modular videos are currently available that cover the syllabus of a comprehensive undergraduate course in Numerical Methods for Engineers. The motivation for the development of the audiovisual lectures was based on a pilot study that showed that the examination performance and student satisfaction increased with the availability of audiovisual lectures. A final assessment of these resources made via a video analytics tool shows increasing popularity of the videos, gives insight into the audience attention, and presents demographics by gender, age, and geography. In addition, a summative rating survey of the courseware shows significant increase in the value of the quality of content and enhancement in student learning.

Introduction

In 2008, National Science Foundation (NSF) of the USA published a task-force report [1] on cyberlearning (defined as “learning that is mediated by networked computing and communications technology”). The writers of this report emphasized that cyberlearning can transform education as it offers a new approach to learning by offering the content through multiple context and platforms. In the same year, the National Academy of Engineers [2] came up with a list of 14 challenges for the 21st century, and one of those challenges is Advanced Personalized Learning. This is an acknowledgment that each of us learns differently and that we need to make resources available for individualized reliable learning. Recently, more and more research has been focused on exploring ways to improve the quality of online materials and the variables that relate to enriching student-learning experiences [3,4].

One of the avenues of providing online materials for higher education has been the availability of open courseware [5]. Worldwide, there are more than 200 open courseware initiatives. One such initiative at the University of South Florida (USF) includes the course in Numerical Methods for Engineers (http://numericalmethods.eng.usf.edu). Most open courseware available on the web though is limited to items such as syllabus, reading assignments, class notes, problem sets, and examinations. However, the Numerical Methods courseware at USF has gone beyond the existing norms of content in both scale and completeness. It includes other components such as primers for pre-requisite courses, textbook chapters, worksheets written in several computational software packages, PowerPoint presentations, multiple-choice tests, anecdotal stories, laboratory exercises, and real-life application examples from multiple engineering majors.

In addition, not just for the completeness of such courseware but also at its nucleus, audiovisual lectures for a complete course are also included. In fact, lecture videos are recommended [6] objects for all different learning styles - apprenticeship, incidental, inductive, deductive, and discovery. This paper describes the experience of preparing, recording, uploading, organizing, and assessing the audiovisual lectures for the Numerical Methods for Engineers course taught at USF.

Motivation

In addition to the current literature [7-8] which supports the importance of audiovisual lectures in courseware, the motivation to develop the audiovisual lectures for the whole course was the results of a pilot study [4] co-authored by the first author. The study consisted of comparing four instructional delivery modalities for a single instructional unit (Nonlinear Equations) of the Numerical Methods course over separate administrations (2002-06).

1. Modality#1: Traditional lecture (traditional face-to-face mode without benefit of web-based materials) in Summer 2002.
2. Modality#2: Web-enhanced lecture (face-to-face mode with active learning via multiple-choice questions and small calculation questions, and benefit of supplementary web-based content) in Summer 2003.
3. Modaility#3: Web-based self-study (learning only via primary content available on the web) in Summer 2004, and
4. Modality#4: Combined web-based self-study and classroom discussion (learning via primary content available on the web outside the classroom, and followed by Q&A classroom discussion) in Summer 2006.

Audiovisual lectures for Nonlinear Equations included all the course syllabi topics of 1) background of nonlinear equations, 2) bisection method, and 3) Newton-Rapshon Method, and were made part of the web-based content that was available only for Modalities #3 and 4. Since this was a time (2004-06) when broadband connections were not as prevalent in residential areas, the audiovisual lectures were also available on CDs.

To compare the effectiveness of delivery modalities, student achievement on a multiple-choice examination (part of the final examination), and a student satisfaction survey were used. We found that the use of web-based modules provided students with enhanced likelihood to succeed in the course. Students consistently in the Modality#2 and Modality#4 cohorts performed better on achievement measures (Table 1), and students in the Modality#2 cohort tended to have more favorable survey ratings as compared to the other three groups of students (Table 2). Most respondents in general, considered the use of distance learning modality as positive.

Table 1. Final examination averages (maximum of 4) for different instructional delivery modalities (N=number of students).

	MODALITY			
	Modality #1: Traditional Lecture (N=42)	**Modality#2: Web-Enhanced Lecture (N=27)**	**Modality#3: Web-Based Self Study (N=49)**	**Modality#4: Combined Self Study & Class Discussion (N=56)**
Final Examination Average (Standard Deviation)	2.14 (0.814)	2.51 (1.12)	2.27 (0.953)	2.68 (1.01)

Table 2. Student satisfaction level average (maximum of 7 on scale of 1-truly inadequate to 7-truly outstanding) for different instructional delivery modalities (N=number of students).

	MODALITY			
	Modality #1: Traditional Lecture (N=42)	**Modality#2: Web-Enhanced Lecture (N=27)**	**Modality#3: Web-Based Self Study (N=49)**	**Modality#4: Combined Self Study & Class Discussion (N=56)**
Satisfaction Level Average (Standard Deviation)	4.48 (0.174)	5.80 (0.135)	4.26 (0.208)	4.66 (0.226)

The findings of the data supported the contention presented by other research [9-14] that students find different and varied resources helpful. The use of multiple methods within the web modules created, e.g., textbook chapters, audiovisual lectures, PowerPoint presentations, worksheets, multiple-choice tests, provide a variety of resources that are helpful to specific students depending on their learning style. Furthermore, the findings of the achievement data supported that some students were highly comfortable with the distance modalities and liked the flexibility it provided, but the need for personal interaction with the instructor was also evident. This indicated that a mix of the two modalities, in some form or another, was most beneficial to many students. Detailed description of the statistical assessment and data interpretation is given in Ref [4].

The Development and Deployment of Audiovisual Digital Content

Motivated by the results of the above study and the NSF report [1] on cyberlearning, and as part of the multiple-context and multiple-platform development of the online resources for the course, in Spring 2009 and Spring 2010, audiovisual lectures for a comprehensive course in Numerical Methods were developed and uploaded to YouTube (http://www.youtube.com/numericalmethodsguy). In this section, we discuss the experience of the development and deployment of these videos.

At USF, we have several studios for distance learning. These are used for teaching off-campus students synchronously and asynchronously. Rather than simply recording such lectures in a classroom setting and uploading to an OCW website, as has been done by some of the open courseware initiatives [15-18], we took a different approach. The lecture videos were recorded in a university studio without any students, and were recorded in short but complete segments. For example, the topic of Newton Raphson-Method of solving nonlinear equations was divided into short segments of a) derivation, b) example, c) pitfalls, d) application to finding square root of a number, etc. This allows the user to choose the modules they need to study or review, and hence achieve a neutral pedagogy for wider acceptance.

The recordings were scheduled for two days per week in 75-minute sessions. Most of the recorded lectures used the whiteboard, while based clearly on suitability, less than a quarter of the lectures were recorded via a Smartboard [19]. The recordings involved two remotely operated cameras manned by two technicians in a control room. The files of the recordings were encoded by a third technician and were given to the first author as Windows Media Player (wmv) files at the next recording session.

If a subtopic could not be explained in less than 10 minutes (YouTube limited the video lengths to 10 minutes before Summer 2010 at which time they increased the limit to 15 minutes), the resulting audiovisual file was reviewed by the first author to find suitable points where they could be broken into less than 10-minute segments. This information was given back to the third technician who would then split the video file into smaller wmv files, and add the appropriate beginning and end slates to each segment. To keep these segments organized and sequential, playlists were developed on YouTube as well as the course website [20].

The videos were uploaded to the YouTube site (http://youtube.com/numericalmethodsguy) with topic name, tag words, and a brief description. This process of recording, encoding and uploading continued for 22 weeks (14 weeks in Spring 2009 and 8 weeks in Spring 2010) until all the videos for a comprehensive numerical methods course were completed. More than 250 videos are now available on the YouTube site (Figure 1), at the numerical methods website (http://numericalmethods.eng.usf.edu/videos/numerical_methods_course.html) on a single webpage, and at a site for mobile users (http://numericalmethods.eng.usf.edu/mobile/).

The services of developing these videos come at an expense. With three technicians, a supervisor and the rental of the studio, the total expense is estimated at $10,000 for the whole course. This is in line with the estimate of $10,000-$15,000 that MIT OCW [21] gives for putting a course online.

One may appreciate the pedagogical reasoning for modular nature of the videos, but at the same time wonder why use YouTube and take the effort of breaking lectures into 10-minute segments when one could have put these videos on the university server, where the videos equally would be accessible worldwide. The following were the main reasons to do so.

1. One uses bandwidth of YouTube as opposed to that of the university servers.
2. One uses compression technology of YouTube for reducing the size of the video files considerably without sacrificing quality. This has been critical in reaching users who have slow internet connections.
3. The videos get Google-searched immediately.
4. One gets wider publicity to the resources.
5. The author was forced to think pedagogically about presenting information in small chunks to modularize the course content. This has been critical in keeping the pedagogy neutral, and has eased barriers for adoption by instructors and students alike.
6. Users can comment and give feedback on the quality of instruction. Questions asked by users can be answered and archived immediately.
7. Mistakes can be annotated via a simple interface of YouTube.
8. Resources of other developers are automatically shown next to the developer's video, hence improving the diversity of the available resources and instructional methods.
9. The free "Insight" program of YouTube keeps statistical track of usage, demographics, regional popularity, attention, etc (this is discussed in detail in the next section on assessment).
10. Recently YouTube included a speech-recognition feature of close captioning. This YouTube feature still requires considerable improvement in its accuracy, especially for videos with a technical content.

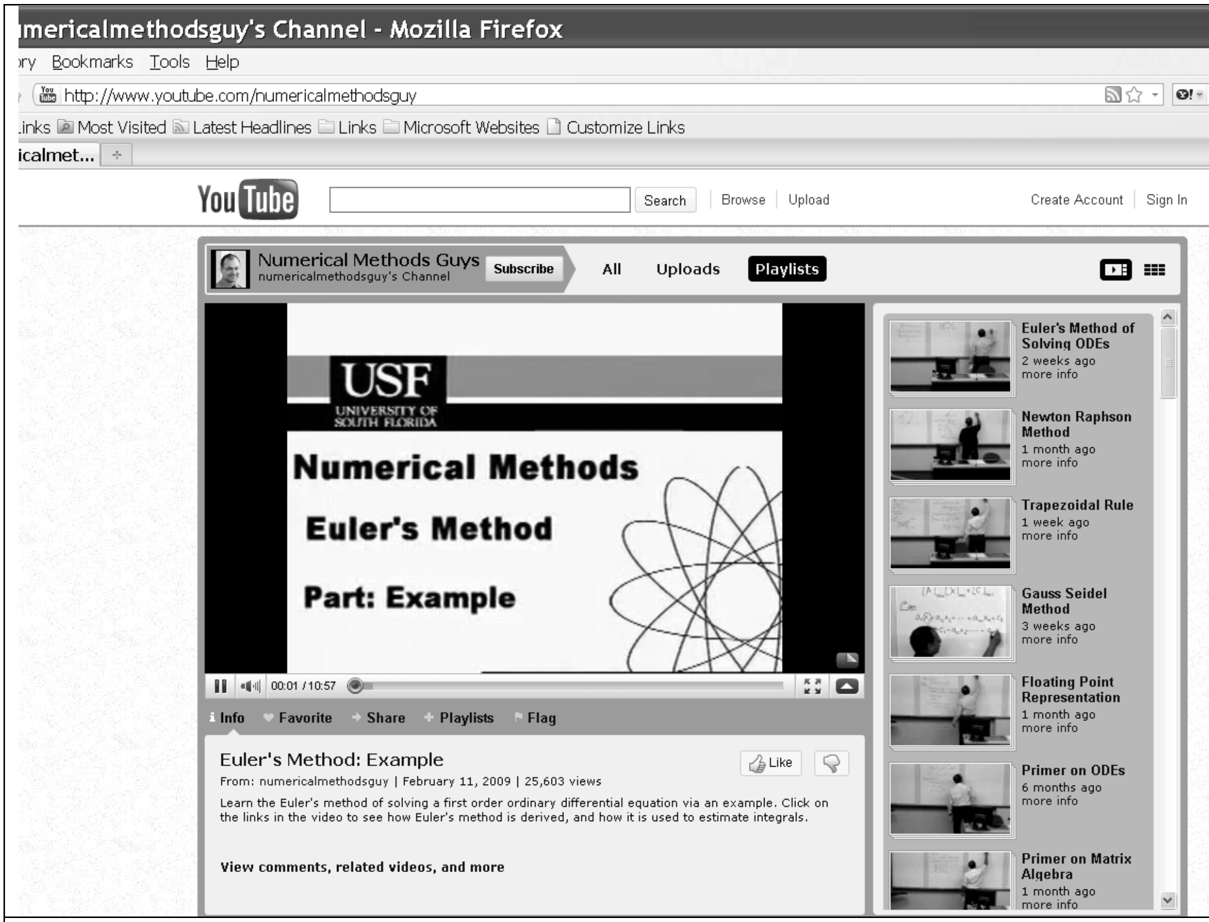

Figure 1. Home page of the numerical methods YouTube site.

Assessment

In addition to the pilot study [4] summarized in the previous section, to measure the effectiveness of the YouTube audiovisual lectures, two assessment tools were used. These were 1) the video analytics tool provided by YouTube called Insight® [22], and 2) a summative rating survey of the courseware that included a subset of questions directly related to content and media enhancements.

Assessment by Insight®: "Insight is YouTube's external facing analytics and reporting product that enable anyone with a YouTube account to view detailed statistics about the videos that they upload to the site.[23]". All the metrics are measured transparently, and these include number of views, demographics by age, gender and geography, relative popularity, and how viewers discover the videos.

Figure 2 gives the summary of the Insight® Statistics for a typical four-month period of a Spring semester (January 1, 2010 – April 30, 2010). It shows that the video views were increasing at a steady rate with a daily average of about 1,300 views. The most popular videos are listed, demographics are given by gender (Male -82%, Female -18%) and age (23% in 18-24 range, and 24% in 45-54 range), and popularity is shown by geographic locations. The Insight® tool also shows audience attention for each video, which is a measure of the ability of a video to retain the audience.

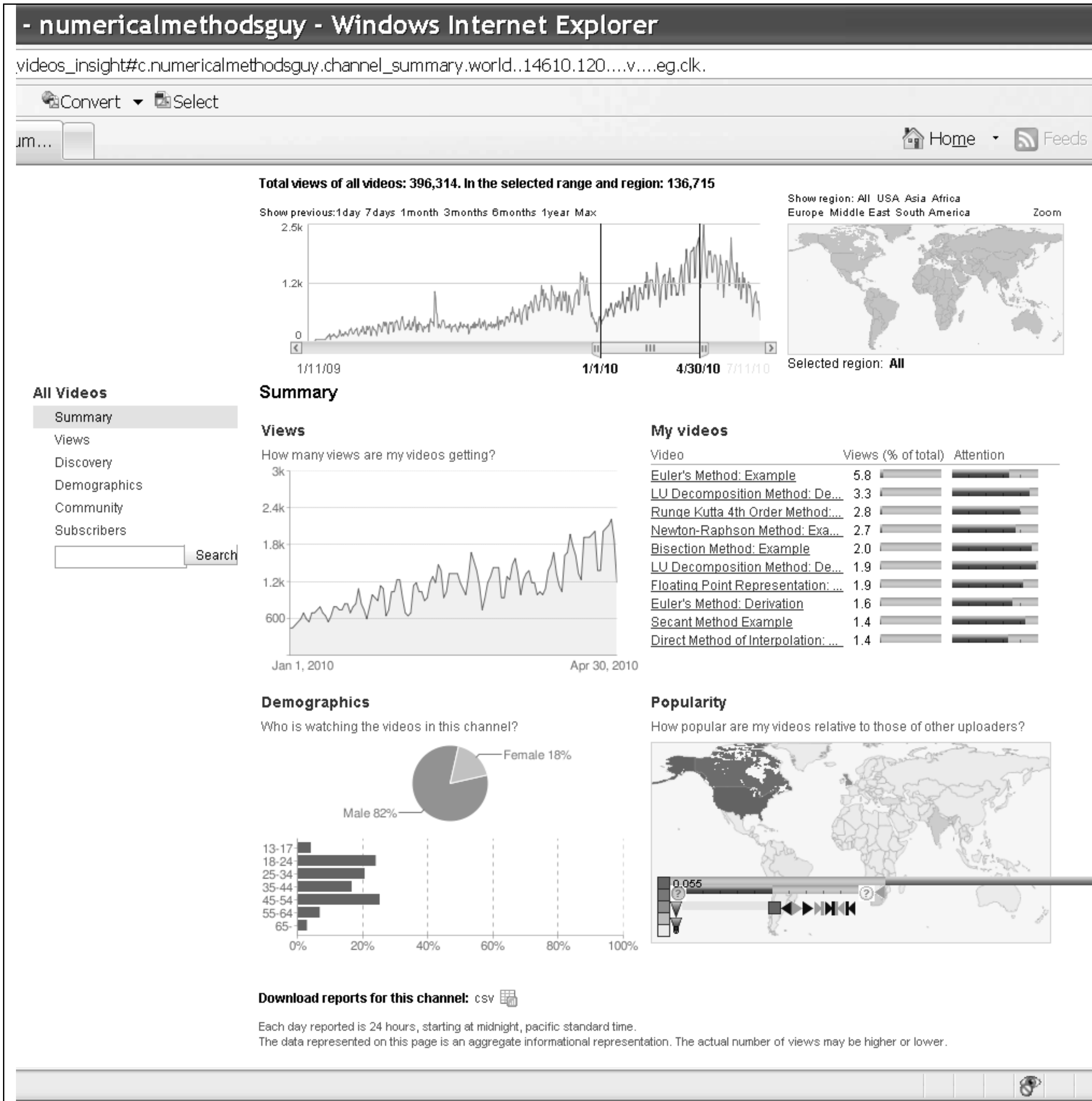

Figure 2. The Insight statistics for the YouTube site.

Instead of uploading the videos to a server at the university, our decision to upload them to YouTube is appreciated even more because 57% of the video views were made by users who clicked on related videos on YouTube or found the video via the search option at YouTube. Also, 12% of the video views were made via viral sharing of the videos, that is, the videos were shared via email, instant messaging, and direct copying of the video URL into the address of a browser.

In addition to the above statistics, each video is rated and commented on by logged-in YouTube users. This qualitatively assesses how the videos are being used and accepted by the general audience. Course-related questions asked by the users through the comment section are answered promptly. Some of the general comments on the videos are given below.

- *I've never had a lecturer that can explain concepts as clearly and quickly as you* *can. Thank you so much, you have really helped!!*

- *If all professors can lecture like you, no one would fail in this world.*
- *First off...thanks a ton!! ....I am expecting an A in numerical methods course this semester....extremely grateful student :)*
- *Got an A in my modeling methods class thanks to you. THANK YOU!!*
- *Man, it is the most interesting and easiest course I have ever taken. At least it makes sense (lol). Thank you very much... it's people like you who make the world a better place. God bless you!!!!*
- *You rock! I mean numerically.*

More than 95% of the comments were positive, and the few negative comments were generally related to the instructor's accent or a few typographical mistakes in a small number of videos. The typographical mistakes were immediately annotated with the correct text, while a few videos that had propagating mistakes were replaced with re-recorded versions.

Summative Rating of Courseware: Using a five point Likert scale of 0 to 4 (0- absent, 1-poor, 2-average, 3-good, 4-excellent) on an 18-question survey, students at USF assessed the complete courseware on major factors of content, learning, usability, and technology. Out of the 18 questions asked in the survey, three questions directly measure the effect of introducing the complete set of audiovisual lectures set. The average ratings of these questions are given in Table 3.

There is a significant increase in the ratings of all three questions from Spring 2007 to Spring 2010. In Spring 2007, videos were available for only for two of the eight topics, and in Spring 2010, the videos were available for the whole course.

In the same survey, we also asked qualitative questions such as - What do you like most about the courseware? In response to this question, in Spring 2010, 17 out of 55 responses mentioned the availability of videos. Some of these comments included

- *The videos allow students to review and better understand what was taught in class, excellent tool.*
- *The YouTube Videos. I prefer to listen in class rather than take notes. I feel this helps me pay more attention to what the instructor is saying. That being said the YouTube videos really helped with filling in my notes, mental lapses, and overall understanding of the material that I was unable to obtain from regular class hours.*
- *Specific links to the videos for the chapters covered.*
- *I really liked the online videos*
- *That it has many videos related to the class topics*
- *The links to the YouTube videos*
- *What I liked the most about this website were the videos that help reinforce the class lectures.*

Table 3. Average ratings (scale of 0-absent to 4-excellent) on questions on content and media enhancements.

Survey Question	**SPRING 2007 (N=50)**	**SPRING 2008 (N=37)**	**SPRING 2009 (N=39)**	**SPRING 2010 (N=56)**
The quality of the content was ____	3.14	3.22	3.26	3.69
The quality of media such as simulations, audio and video was ________	2.71	2.83	3.23	3.38
How well the media enhancements such as simulations, videos, etc helped you learn was ___	2.63	2.58	3.13	3.30

Conclusions

As a nucleus of any courseware, and as a component of resources that is recommended for all learning styles, a complete set of modular digital audiovisual lectures has been developed for a comprehensive course in Numerical Methods. The experience of how these videos were recorded, uploaded, organized, and assessed is shared. An assessment of the resources made via a video analytics tool shows its gaining popularity and impact amongst users worldwide. A summative rating of the courseware shows significant increases in the value of the quality of content and enhancement in student learning.

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