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Investigation of Video Tutorial Effectiveness and Student Use for General Chemistry Laboratories

Jessie Key and Michael Paskevicius

ABSTRACT - The effectiveness and use of video tutorials as an educational tool for general chemistry labs was examined over the Fall 2013 semester using web analytics tracking functions including Google Analytics and data sourced from a video streaming server. Data such as the number of pageviews, number of plays, playthrough ratio, devices, and operating systems used were collected throughout the semester. In addition, a short survey was conducted for students and instructors to determine the perceived influence the video tutorials had on students' learning. The analytic and survey data obtained support that most students used the video tutorials to prepare for labs and the lab exam. Most students perceived the video tutorials increased their understanding and confidence levels in the lab.

Keywords: First-Year Undergraduate, Chemical Education Research, Multi-Media-Based Learning, Student-Centered Learning, Educational Video, Video Recorded Lab Tutorials

Introduction

While textbooks, lectures, and other traditional instructional methods remain vital modes of transferring knowledge, increasingly, digital media is being used as an alternative method, or supplement, to traditional teaching methods. Screencast videos are short video captures of a user's computer output with narration. Using the computer desktop as the "stage," a screencast may display a software application, "chalk-talk" using a drawing program, PowerPoint presentation, web page, etc. Previously, screencast video tutorials have been used to supplement chemistry lecture courses with mini-lectures, homework, and exam solutions "chalk-talks," and have been shown to elicit improvements in student performance or perceived improvements in student understanding (Hudson & Luska, 2013; He, Swenson & Lents, 2012; Green, Pinder-Grover & Millunchick, 2012; Revell, 2014).

While much attention has focused on video tutorials for classroom based learning environments, applications in the laboratory learning environment have been less thoroughly examined. Laboratory work is an important part of many science courses, where general, practical, and course specific theory and skills are learned (Reid and Shah, 2007). Video resources may be accessed on demand by students to prepare for a laboratory experiment or for review before assessment. Previous research suggests that students perceive on demand video tutorials to help support their learning and increase flexibility for reviewing materials (He et al., 2012). The design and content of the video must be carefully considered to match the instructional objective for the course. If students perceive that they might glean all of the instruction necessary from the video alone, this has been shown to reduce in class attendance (Hudson & Luska, 2013). The objective of creating on demand video tutorials, when face to face class time is still expected, should be to expose students to concepts which might be discussed and reinforced in class or in lab (Green et al., 2012). A recent study has qualitatively examined student perception and comfort level using video resources for two chemistry experiments (Teo et al., 2014). The authors speculate improved theoretical understanding and lessened student anxiety from observation in the lab and interviews with students.

Data was collected to investigate the effectiveness and use of video tutorials as an educational tool for general chemistry labs at Vancouver Island University (VIU). Traditionally, laboratory components use a laboratory manual to convey both the theory and instructions to the students. However, students can arrive to lab without having fully read or understood the written explanations in the lab manual which may limit the value of the lab experience (Kirschner, Meester, Middelbeek & Hermans, 1993). At the start of the lab period, instructors highlight important concepts or techniques, safety concerns, and instructions with a short pre-lab talk, then allow the students to complete the tasks of the lab. The pre-lab talk is often kept short to allow sufficient time for students to complete the lab objectives. As well, dem-

onstrations may not always be clearly viewed by all students with typical lab sizes of 12-22 students. Furthermore, if a student was absent or inattentive during the lab demonstration they would miss important instruction.

Methodology

A series of short (2-7 minute) screencast and live-action videos was created to supplement existing methods for conveying aspects of laboratory safety, theory, and techniques. Videos were uploaded to VIU's Kaltura based Video Media Repository (VIUTube) which allows users to consume video on computers and mobile devices or tablets. The videos were then embedded into the course's learning management system (LMS), Desire2Learn, for all sections of general chemistry at VIU in the Fall 2013 semester. Each video was coded with a VIUTube and Google Analytics tracking code on a unique web page in the LMS, allowing for the capture of user access data collection for each video.

To assess the perceived effectiveness of the video tutorials, voluntary surveys were conducted with the students and laboratory instructors at the end of the semester. The data presented includes the results of the survey and web analytics data in order to demonstrate the effectiveness and use of video tutorials in general chemistry labs.

Participants

The subjects of this study were students enrolled in the first year undergraduate chemistry courses CHEM 140 "Chemistry Fundamentals I" and CHEM 150 "Engineering Chemistry" during the fall semester of 2013. CHEM 140 and CHEM 150 have a common laboratory component offered Mondays through Thursdays, where all but one experiment is shared for both groups. Students participated in a total of ten laboratory periods throughout the semester, including one period of written examination. There were 229 students enrolled in these courses at the start of the semester and 184 students enrolled at the end of the semester.

Video Production

Important theory and demonstration topics were identified from the course lab manual and discussed with the laboratory teaching faculty. Eighteen short video tutorials and demonstrations were generated ranging in length from 2:00 to 7:15 minutes (Appendix A).

Live action demonstration components of the videos were filmed using a JVC 8GB High-Definition Flash Memory Camcorder (GZ-E220BU). Audio voiceovers were recorded using a Blue Microphone SnowBall iCE USB Microphone (78908Q) Model Number: 1974. Video annotation was performed using a Wacom Bamboo Capture Pen & Touch Tablet (CTH470M). Audio editing was performed using the freeware software Audacity (http://audacity.sourceforge.net/). Video capture and some video editing was performed using the freeware software Active Presenter (http://atomisystems.com/activepresenter/). Additional video editing was performed using Windows Live Movie Maker (version 2011) and Adobe Premiere Elements 9.

Video Delivery

Video delivery was performed using VIUTube, a campus streaming video and audio platform. The service is very similar to the popular video streaming service YouTube, but hosted at VIU and supports private, advertisement free video streaming. VIUTube supports mobile video upload and consumption, so students can watch video on demand on any device.

Results: Student Usage – Analytics Data

Examining the number of pageviews over the length of the laboratory course (Figure 1) several trends emerge. Generally, the number of pageviews reach a maximum midweek (Tuesday and Wednesday) and are at a minimum on Friday and Saturday. This trend suggests students watched the video resources the day before or the day of their laboratory experiment, as 2-3 laboratory sections were run daily Monday through Thursday.

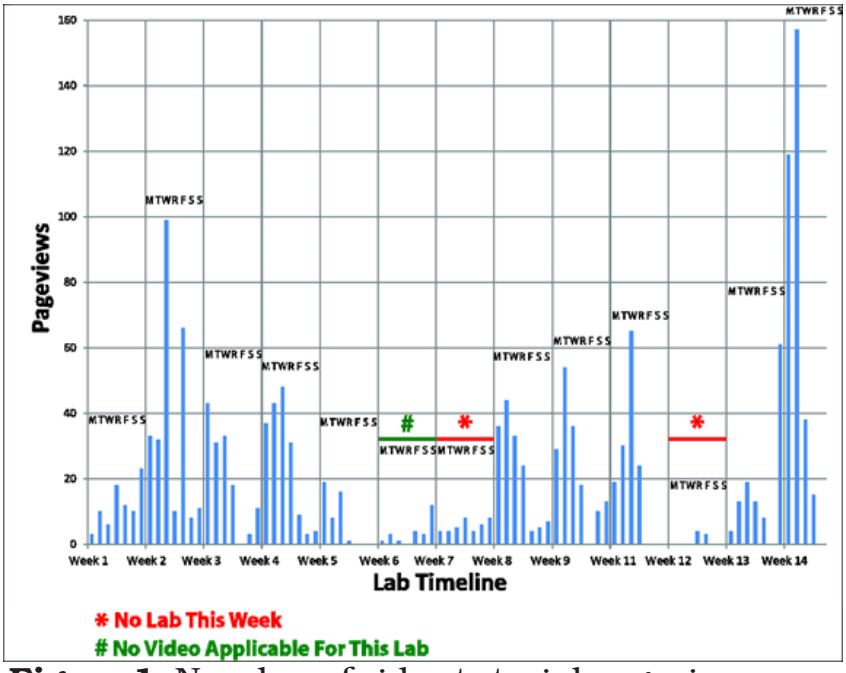

Figure 1. Number of video tutorial pageviews per day during the fall 2013 semester.

There was a noticeable increase in the number of visits and pageviews during the week of the laboratory exam (Week 14), indicating that students were using the videos to review for the exam.

Individual videos were played 33 to 122 times each, with a mean value of 63 plays (Appendix A). The average view time per video ranged between 44.9% to 82.7% of the video's total length, with a mean value of 62.0%. The playthrough ratio (number of times the video was watched completely/total number of plays x 100%) of each video ranged from 41.9% to 87.5%, with a mean value of 68.6%. A plot of playthrough ratio vs. video length showed a very weak negative correlation (R-squared = 0.2) indicating that in our case video completion is not dramatically influenced by video length (Figure 2).

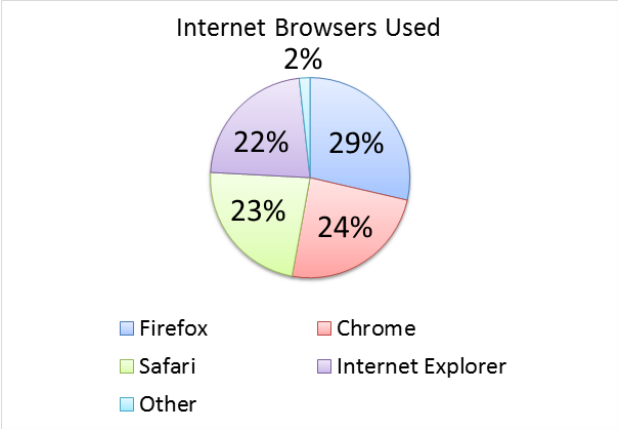

Figure 3. Internet browsers used to access the video tutorial resources.

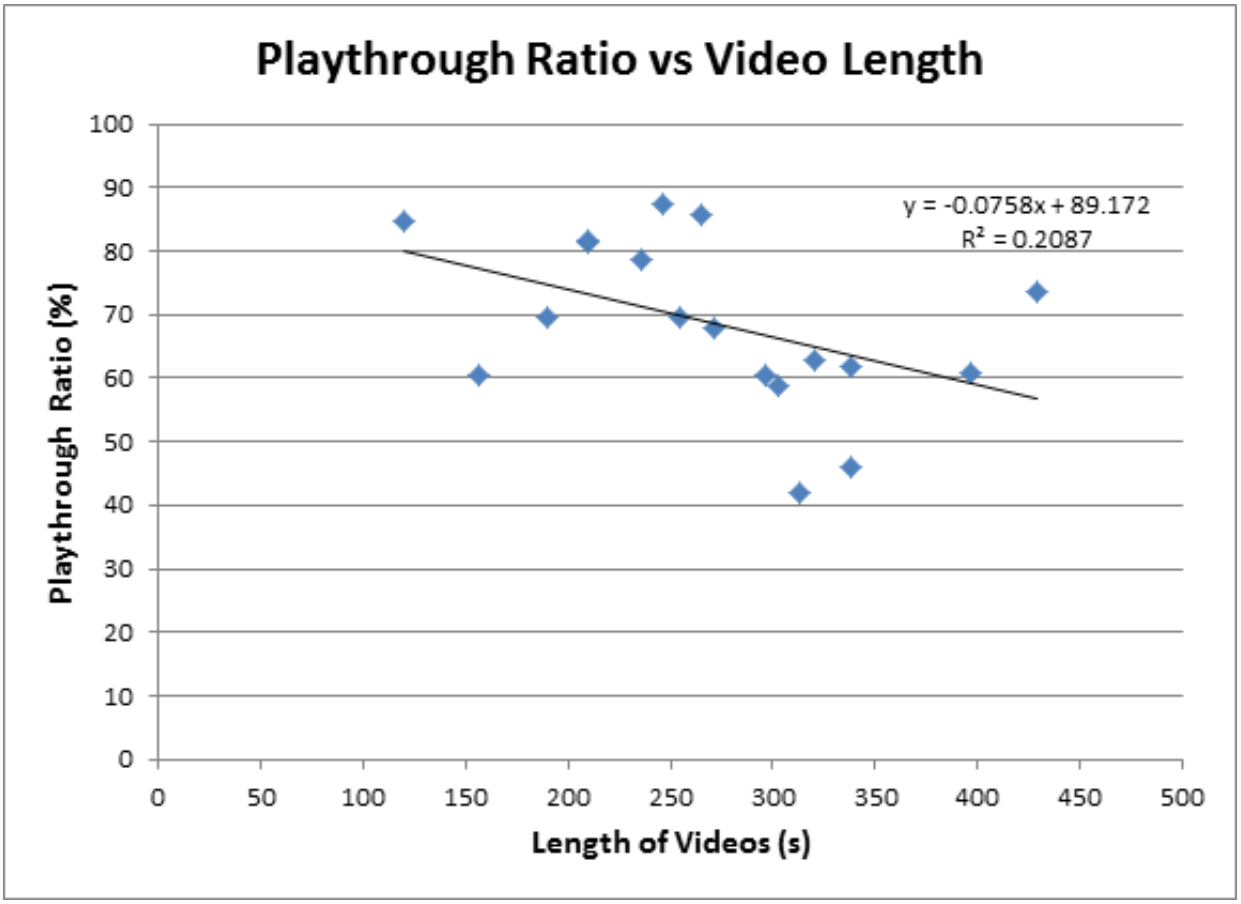

Figure 2. A plot of playthrough ratio versus video length for the video tutorials.

Students accessed the video resources from several popular Internet browsers, including Firefox, Chrome, Safari, and Internet Explorer (Figure 3). A slight preference for Firefox was observed, however, each of the four most popular browsers ranged between 22 and 29% of visits. Campus computers were installed with only Firefox and Internet Explorer browsers.

Students accessed the video resources from a variety of devices running on various operating systems (Figure 4). Windows was the most popular operating system used, accounting for 69% of all visits, followed by Macintosh (17%), iOS (12%), and Android (2%). A clear preference for iOS was shown over Android for mobile devices; iOS devices accounted for 87% of mobile device visits, while Android devices accounted for 13%. Cam-

pus computers operate using Windows exclusively.

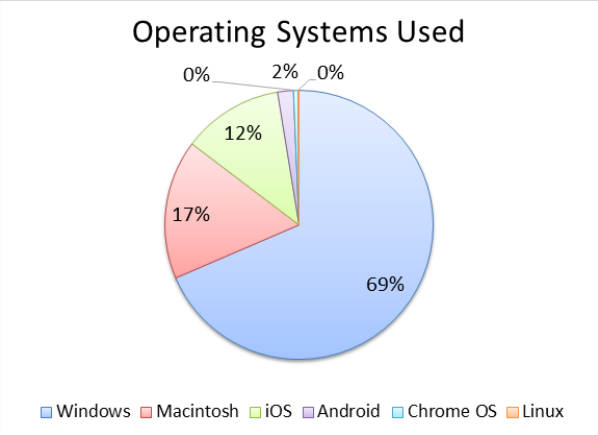

Figure 4. Operating systems used to access video tutorial resources.

Student Survey Responses

A voluntary student survey was performed at the end of the semester to evaluate student usage and perception of the video tutorials (Table 1). A total of 78 students chose to complete the survey. The first four questions probed how students consumed the videos. 66% of survey respondents watched some or all of the videos, finding them slightly to very helpful, while 33% of survey respondents admitted to not watching the video tutorials at all. Most students who watched the videos (81%) found no technical problems using the videos, with 12% experiencing occasional technical problems and 8% finding certain devices having technical problems. Of the students who watched the videos, the vast majority (94%) indicated they used the videos to prepare themselves before lab periods. Other popular uses of the videos included preparing for lab quizzes/tests (50%), and to help answering post-lab questions (31%). Most students (77%) indicated they watched videos from start to finish, while some watched large chunks of the video to look for certain information (15%).

Two questions were posed to determine how students perceived the usefulness of the videos. Most students (83%) agreed or strongly agreed that the videos gave them a deeper understanding of the lab materials, and 88% agreed or strongly agreed to feeling more confident in the lab after watching the video tutorials. Students indicated that when they did not watch the video tutorials, it was primarily due to forgetfulness (48%), insufficient time (48%) or that they already felt confident with the material covered (36%).

Table 1. Summary of Voluntary Student Survey Results

1. How helpful were the video tutorials?			
Did not watch them	Not at all helpful	Slightly helpful	Very helpful
33%		15%	51%
2. Did you experience any technical issues while viewing the videos?			
Yes always	Yes sometimes	No not at all	Only on certain devices
	12%	81%	8%
3. What are the reasons you watched the video tutorials? (Check all that apply)			
To prepare yourself before lab	To help answering post-lab questions	To prepare for lab quizzes/lab exam	other
94%	31%	50%	12%

4. People use video tutorials in many ways. Which is the single best description of how you typically used the video tutorials?				
Watched entire video from start to finish	Watched large chunks looking for information	Browsed around	Re-watched certain segments (based on my homework responses)	Went to specific points to review
77%	15%	2%	4%	2%

- *Continued*

5. Rate your level of agreement with the following statement: I have a deeper understanding of the lab material because of the video tutorials				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
2%	2%	13%	71%	12%
6. Did you feel more confident in lab if you watched the corresponding tutorial videos before attending lab?				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		12%	61%	27%
7. If you did not watch certain tutorial videos, what are the reasons? (Check all that apply)				
Confident with the material already	Forgot	Not enough time	Technical Problems	Other
36%	48%	48%	4%	4%

Laboratory Instructor Survey Responses

A survey of the five laboratory instructors was performed at the end of the semester to evaluate laboratory instructors' perspectives on the use of video tutorials (Table 2). This survey revealed that although some (20%) were initially apprehensive about using video tutorials with the lab, all lab instructors preferred to keep the tutorials available as part of the course in the future. Most laboratory instructors noticed some increase in student confidence (60%), and that some students required less assistance throughout the lab period compared to previous semesters. However, lab instructors did not observe a noticeable increase in student grades compared to previous semesters.

Table 2. Summary of Voluntary Lab Instructor Survey Results

Question	Lab Instructor Response (%)					
	Not Applicable	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Students appeared more confident in lab this semester compared to other semesters	20%			20%	60%	
2. Students required less assistance in the lab this semester compared to other semesters	20%			20%	60%	
3. Students appeared to ask fewer questions about the specific content covered in the videos				40%	60%	

- *Continued*

4. Students appeared more prepared in lab this semester compared to other semesters	20%			40%	40%	
5. Student marks seemed higher in lab this semester compared to other semesters	20%		20%	60%		
6. I had apprehensions about using the video as they explained things differently than I normally would in class	20%		40%	20%	20%	
7. I would prefer to keep lab video tutorials available for this course					40%	60%

Discussion

Limitations and Challenges of Video Tutorial Usage

There are several limitations which may hamper the use and effectiveness of video tutorials for use in general chemistry laboratories. The technical skill and amount of time required to produce the videos by instructors is significant. Although the digital camera and software used to make the videos were fairly user friendly, some individuals may require additional training and practice in their use to become comfortable with these technologies. Once comfortable with the technology, the process of recording and editing digital video and audio media can still be time consuming. Recording and editing a single five minute video composed of live-action demonstrations, screen capture, and audio can take several hours.

The sustainability or "shelf-life" of the video resource is another limitation which should be considered. Ideally, video tutorials can be archived and reused in many subsequent years. However, it is advised that during the design and recording of video tutorials, a conscious effort should be spent avoiding the use of vocabulary, equipment or sound effects which may rapidly become outdated or identify the age of the video resource. Furthermore, videos should be free from context specific information as much as possible. For example mentioning times, dates, course codes, or page numbers should be avoided as these details could change as the videos are used in new semesters or with new versions of a lab manual or textbook.

Ensuring access to the video resources for all students, regardless of device or operating systems used, is a significant challenge. In this study, only minor outages and technical difficulties were experienced using the Kaltura based Video Media Repository (VIUTube) and a wide variety of devices and operating systems were supported. The voluntary student survey indicated that only 4% of students chose not to watch certain videos due to technical problems.

Advantages and Benefits of Video Tutorial Usage

Video tutorials and demonstrations enable instructors to clearly show the theory, techniques, or equipment that will be used in their laboratories to students in a time- and location-flexible manner (He et al., 2012). Video tutorials may also provide additional benefits to students with learning disabilities or English as a second language (ESL) through appropriate use of captioning and the ability for students to replay or pause the tutorials (Revell, 2014).

Conclusions

The video tutorials and demonstrations examined in this study have been used by most students in the general chemistry Fall 2013 cohort (66%). The majority of students that did view the video tutorials identified that they gained a deeper understanding of the lab materials (83%), and had increased confidence entering the weekly labs

(88%). As well, all of the lab instructors surveyed supported keeping laboratory video tutorials available for students in the future. This study supports that video tutorials are an effective and useful way to enhance the student learning experience in the general chemistry laboratory, providing a dynamic learning experience beyond the written laboratory manual. Furthermore, this study reinforces that the design of on demand instructional videos, where face to face time is still expected, must be thoughtfully designed in order to complement and enhance contact time with students and not provide an alternative to attending lab or class.

Associated content

Video tutorials and other teaching resources not mentioned in this paper may be found on the author's website http://wordpress.viu.ca/key2chem/.

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Appendix A: VIUTube analytics data summary.

	Video Name	Video Length (min)	Plays	Minutes Viewed	Average View Time (min)	Impressions[a]	100% Playthrough	Playthrough Ratio[b]
1.	Unit Conversion	5.05	34	87.12	2.33	48	20	58.82
2.	Significant Figures	5.35	43	120.38	2.47	55	27	62.79
3.	Volumetric Glassware	4.52	53	149.07	2.48	74	36	67.92
4.	Titration	3.93	113	343.25	3.02	137	89	78.76
5.	Stoichiometry	5.22	43	113.46	2.38	55	18	41.86
6.	Precision and Accuracy	6.62	41	167.07	4.04	49	25	60.98
7.	Experimental Error	3.17	36	83.13	2.18	47	25	69.44
8.	Plotting a Calibration Curve in Excel	5.63	122	353.48	2.53	155	56	45.9

- *Continued*

9.	Lab Orientation and Safety (1 of 2)	4.95	33	108.90	3.18	66	20	60.61
10.	Lab Orientation and Safety (2 of 2)	2.60	33	51.35	1.33	50	20	60.61
11.	Using a Viscometer	4.10	80	293.15	3.39	93	70	87.5
12.	Collection of Hydrogen Gas over Water	4.42	106	403.05	3.48	128	91	85.85
13.	Vacuum Filtration	2.00	52	88.00	1.41	64	44	84.62
14.	Melting Point	3.50	70	208.25	2.58	80	57	81.43
15.	Running a TLC	4.25	56	149.82	2.40	66	39	69.64
16.	TLC theory	5.63	63	229.55	3.38	77	39	61.9
17.	Interpreting an IR	3.50	55	154.09	2.48	73	45	81.82
18.	UV-Vis (Spec 20) Use and Theory	7.15	106	518.43	4.53	139	78	73.58

a. Impressions are defined as the number of times the page is seen.
b. Playthrough ratio is number of times the video was watched completely/total number of plays x 100%.

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