https://doi.org/10.48009/3_iis_2020_126-134

Issues in Information Systems
Volume 21, Issue 3, pp. 126-134, 2020

IMPACT OF STUDENT ENGAGEMENT STRATEGIES ON VIDEO CONTENT IN LEARNING COMPUTER PROGRAMMING AND ATTITUDES TOWARDS VIDEO INSTRUCTION THAT WAS DEVELOPED BASED ON THE COGNITIVE THEORY OF MULTIMEDIA LEARNING

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ABSTRACT

Students in multiple sections of introductory and advanced Python programming sections that were delivered in an online format over an 8-week period were given surveys on the use and perceptions of the videos in the course. Over 70 videos were produced using the guidelines developed as part of the Cognitive Theory of Multimedia Learning. High levels of video viewing and completed were reported. In addition to overall statistics, ANOVA's were utilized to analyze students grouped on their desire to take online courses and their engagement in the videos as measured by 4 different variables, but weighted on the frequency and timing of re-watching the videos. Results were overall positive with a mean value of 4.5 out of 5 on a Likert type scale for the statement, "Overall the videos have been helpful in my learning Python." Minimal differences were found between the groups based on preference for in=person learning or engagement of the videos.

Keywords: Video, Flipped Classroom, Teaching Programming, Cognitive Load Theory, Cognitive Theory of Multimedia Learning

INTRODUCTION

Video is a common component of online education. Most of the videos are created by the instructors themselves and they can be short or long, can be one take or edited clips put together. Engaging students in online materials, including videos, can be challenging. This research project focuses on two aspects of online videos. The first is the use of Cognitive Theory of Multimedia Learning to create videos that don't overload the student's cognitive limits. The second is to determine how videos are used by students in learning programming, specifically Python programming.

Over 70 short, 5-10 minute, videos were produced for an introductory and advanced Python course and data gathered from 4 sections of the two courses. A 14-question survey to provide feedback to the instructor was the basis for this research. Students were asked about their use of the videos as well as their engagement of the videos, which were housed on YouTube. Viewership statistics from YouTube was consistent with the student responses on their viewing habits and experiences.

Looking at the results of the survey to improve future videos led to the development of 4 research questions which are shown below.

RQ 1 What are students' views on using video tutorials to learn Python?
RQ 2 How do student use the tutorial videos to meet the different learning objects in an online programming course?
RQ 3 What are the differences in video usage and perceptions between students of different engagement levels in a programming course?
RQ 4 How do students' preference for online instruction influence their video usage and perceptions in an online programming course.

A critical literature review of relevant research in this area is presented next, followed by a description of the methodology used in this study for data collection and analysis—the results for each research question provided.

BACKGROUND AND RELATED WORK

Video and YouTube

Video in some form or another has been part of the educational toolbox for decades, but recent developments in both recoding, production and distribution have made video a greater part of online instruction. (Lipomi, 2020). YouTube has over 2 billion active users each month with an average viewing session length of 40 minutes. While Music and gaming videos dominate YouTube most watched channels, “How To” and training videos are also popular (Alsam, 2020). While film and video have been a staple of educational training for decades, the ability of teachers to quickly create their own video keeps getting easier.

Angrave, Zhang, Henricks, & Mahipal(2020) looked at performance in a large programming course when they switched to a video instructional format. The student’s performed better or the same as past students. They also found that low performing students who watched greater than the median number of videos did better in the course than those who didn’t watch more video. This impact of the amount of time watching the videos reflects on this study. The expectation that students who engage more with the videos by re-watching them will have different expectations of the videos. This idea that there are different ways of interacting with the videos is echoed by Bates (2018) who wrote, “students often reject videos that require them to do analysis or interpretation; they often prefer direct instruction that focuses primarily on comprehension. Such students need to be trained to use video differently, which requires time to be devoted to developing such skills.” p.269. This is supported by Costley, Hughes & Lange (2017) who found high levels of video viewing and completion when using instructional design methods when incorporating the video into the course structure.

Flipped Classrooms

Recent research on instructional video focuses on “flipped classrooms” which utilize video and other media content that is accessed before the in-class sessions which become less about information flow and more about application and problems solving. In a 3-year study comparing student performance in a flipped classroom vs a regular classroom, Guy and Marquis (2016) found similar performance in both sets of students. They found motivation to be a bigger influence on student performance than modality of instruction. As instructors look at the types of videos to produce for their instruction, they need to look at why they are using the video. Kolås, Munkvold & Nordseth (2012) found the following ways of using video in teaching, “the use of video as presentation tool, description tool, instruction/ demonstration tool, gaming tool, reflection tool, observation and analysis tool, problem solving tool, drill and practice tool, assessment tool and evaluation tool.” A common form is a video lecture. Loliwe (2018) found that lecture videos aren’t all that helpful to the students,

> In concluding, the video lectures of the same length and content as the face-to-face lectures may not be used as the replacement for the face-to-face lectures when the campuses are shutdown. There are no grounds to do so if the video lectures’ quality and design is poor, and the students who will be using the video lectures are weak in terms of their prior performance and they are not active student s(p222)

In a meta-analysis of 115 studies on flipped classrooms, Van Alten, D. C., Phielix, C., Janssen, J., & Kester, L. (2019) found a positive impact on student achievement by using flipped classrooms. It appears that the best method of using video in teaching is not to replace the instructor with a video of the instructor. In relation to this study, the use of video in conjunction with programming activities mimics a flipped classroom environment but without the in-class meeting. Research in using flipped classrooms when teaching programming concepts included Matthíasdóttir, Á., & Loftsson, H. (2019), who found that the students liked using the videos and that they did use them to prepare for the application of the concepts in the classroom.

Teaching Programming Skills

Teaching computer programming includes both programming techniques, command structure and higher-level concepts. The broader concepts have been labeled Computational Thinking. (Papert, 1980) This concept was originally focused on elementary aged children and researchers such as Wing (2006) expanded Computational Thinking to include, "solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science" (p. 33) This was further refined by Brennan & Resnick (2012) into three dimensions of Computational Thinking; Computational Concepts, Computational Practices and Computational Perspectives. Nouri , Zhang , Mannila & Norén (2020) summarize these domains as "The concepts designers employ as they program", "The practices designers develop as they program" and "The perspective designers form about the world around them and about themselves." (p4). For this study only the first two domains were evaluated.

The concept that teaching programming is a unique endeavor has led to Elçiçek, M., & Karal, H. (2020) to start work on a framework for design of programming videos that is a separate framework than for the development of other training videos.

Novel teaching methodologies often gain the students attention, but this attention may be short lived. Ohashi, et al (2019) measured performance in students given two different video formats. One was just the instructor narrating PowerPoint slides while the other was two puppets teaching the concepts. Initially student's attention was higher for the puppet group, but overall the simple narration over slides showed an increase over the in class teaching and the puppet teaching.

When the students have control over the video, they can control the pace of the video and re-watch sections that they want to review. Shen, Wohn & Lee, M. J. (2019) asked students about in person and online learning of programming skills and languages. They found that students thought that the in person teachers were not efficient in that they had to work with many different students and that the pace of the instruction did not match their learning speed due to the many different abilities of the students in the classroom.

When discussing teaching methods for programming, Muraina, Adegboye, Adegoke, & Olojido (2019) found that a multimodal instructional approach improved performance. Video was only one aspect of the learning experience. This multi modal approach to learning programming leads to the Cognitive Load Theory.

Cognitive Load Theory

Cognitive Load Theory was developed by Sweller (1988) from the principles of the human cognitive model of information processing. The theory proposes three loads that the mind must handle when learning new information. First there is the Intrinsic load, which is how many connections the new material must be made to existing knowledge to be useful. The second is Germane load which is how much effort is needed to make those connections to meet the desired criterion level or outcome. The third is the Extraneous load which is how much cognitive effort is needed to obtain the Germane load from the received message. This theory was then refined into the Cognitive Theory of Multimedia Learning.

Cognitive Theory of Multimedia Learning

This theory, developed by Mayer (2002) suggests that two channels of input, audio and visual combined can increase cognitive throughput, but if either channel is overloaded the negative aspects impact both channel throughput. Some design considerations that utilize this theory were highlighted by Brame (2015) include; 1) Signaling or cueing such as using highlighting, pointers and adding text which will reduce extraneous load 2) Segmenting or chunking of info which reduces overall intrinsic load and 3) Weeding or removing distracting detail which reduces extraneous load and 4) Matching modality – use the audio or visual mode that is most effective at reducing cognitive load.

Other implications of this theory (Mayer & Moreno 2002) include multiple representation principle which states that words and pictures provide decreased cognitive load than just words and the contiguity principle which states that they must be presented together to have this impact. A third principle is the coherence principle which states that cognitive load is reduced when non-message images and sound are reduced in the media. The modality principle is that spoken word over images is superior to written text and images together. Finally, the redundancy principle is that images, and narration is superior to images, narration, and text. Cheah & Leong (2019) studies the Redundacy effect and found that indeed screen and narration was superior to screen narration and text.

Brame (2016) Summed up the use of video as follows:

> Educational videos have become an important part of higher education, providing an important content-delivery tool in many flipped, blended, and online classes. Effective use of video as an educational tool is enhanced when instructors consider three elements: how to manage cognitive load of the video; how to maximize student engagement with the video; and how to promote active learning from the video.

This epitomizes this study in that the goal of the videos used in this study were designed to be short and focused, only use video and narration to reduce cognitive load and to allow the students to follow along with the video by providing multiple program files that were used in the videos.

METHODOLOGY

A 14-question survey was developed that gathered data on how the students used videos in a Python programming course. Thirty students completed the survey. The sample consisted of both graduate and undergraduate students covering 4 sections of an introductory Python and advanced Python programming courses. All students who completed the survey met the minimum passing objectives as written in the course syllabus. Four of the questions used a Likert type scale that ranged from 5 for Strongly Agree to 1 for Strongly Disagree. Four other questions also used a Likert type scale but with the options being 5 for Strongly Prefer video though 1 for Strongly Prefer Written.

Frequencies and means were calculated for the Likert type scale responses for answering research questions 1 and 2. Students were grouped into 4 “video re-watch” groups. ANOVAs were run using this new variable to answer research question 3. Another question on the survey asked about their preference for online instruction. That variable was used as a grouping variable and ANOVA’s were run to answer research question 4.

RESULTS AND DISCUSSIONS

RQ 1 What are students’ views on using video tutorials to learn Python?

The mean was calculated on the percentage of videos the students reported that they started to watch, that value was 80% of the videos posted. A similar mean was calculated for the percentage of videos the students reported to have completed watching, that was also 80%. This should not be read as students reported the same value for starting a video as completing the videos. An examination of the data showed students who watched a lower percentage of videos, but had a higher completion rate and students who started watching more videos, but completed a lower percentage.

Overall, the students reported the videos being helpful in their learning of Python. On the question, “Overall the videos have been helpful in my learning Python.” The mean score on this question was 4.5 out of 5 with the lowest value being 3 (Neutral).

On the question, “I would prefer to have the instruction in person rather than on video.” The calculated mean value on the Likert scale was 4.0, showing they would have preferred an in-person class. This is an interesting feature of this data set, as these 4 sections were converted to online at the last minute due to the worldwide COVID-19 health emergency. The normal selection bias of surveying students in an online class was eliminated.

The students agreed (mean of 4.0) with the statement “Even if I had the instruction in person, the videos would be helpful?” This reinforces the data from above that the videos helped overall with their learning of Python. It is clear from the data the videos were helpful and the students think they are a useful addition to the instruction, at least for assistance with the homework, even if it is an in-person class.

RQ: 2 How do student’s use the tutorial videos to meet the different learning objects in an online programming course?

When asked how they used the videos, the highest count was for “Help with the homework”. Table 1 shows the counts for all questions. It is clear from the data that the videos were used extensively to help with the homework assignments, which were all programming assignments, but that they were also used as a study aid for tests and quizzes.

Table 1. Counts of how videos were used in class

Use of videos in course	Count of times selected	Percent of sample
Help with the homework	29	96%
Prepare for tests	19	63%
Prepare for quizzes	18	60%
Reinforce the class material	16	53%
Replace reading the textbook	14	46%

When asked about their preference for having new topics explained in person or video, 86% responded that they preferred, or strongly preferred video as shown in Table 2.

Table 2. New Topic Preferences

Response	Frequency	Valid Percent
No preference on the method of presentation	3	10%
Prefer Video	12	40%
Strongly Prefer Video	14	47%

When asked, “How do you prefer the weekly introduction?” 60% responded that they preferred, or strongly preferred video as shown in Table 3. Remember these results are from students who reported that they generally prefer in person instruction and actually signed up for in person sections.

Table 3. Weekly Introductions

Response	Frequency	Valid Percent
Prefer Written	1	3%
No preference on the method of presentation	11	36%
Prefer Video	9	30%
Strongly Prefer Video	9	30%

When asked, “How do you prefer having the homework answers explained?” 70% responded that they preferred, or strongly preferred video as shown in Table 4.

Table 4. Homework Answers

Response	Frequency	Valid Percent
Strongly Prefer Written	1	3.3%
Prefer Written	4	13.3%
No preference on the method of presentation	4	13.3%
Prefer Video	8	26.7%
Strongly Prefer Video	13	43.3%

When asked," How do you prefer having the code and coding explained?" 86% responded that they preferred, or strongly preferred video as shown in Table 5.

Table 5. Code and Coding

Response	Frequency	Valid Percent
Strongly Prefer Written	1	3.3%
Prefer Written	1	3.3%
No preference on the method of presentation	2	6.7%
Prefer Video	8	26.7%
Strongly Prefer Video	18	60%

The students clearly preferred having the video available and especially wanted to have the video available when having coding explained. This data supports the previous data when 96% of the sample reported using the videos to help with the programming homework assignments.

RQ 3 *What are the differences in video usage and perceptions between students of different engagement levels in a programming course?*

When looking at student engagement with the videos there were 4 variables to consider. The first was the percentage of videos that the student started watching. The second was the percentage of videos the student completed watching. The third was the percentage of videos the student re-watched right away and the last was the percentage of videos the student re-watched later. An examination of these four variables yielded 4 groups. With the high percentage of videos watched completely the two re-watch variables becomes the most important in determining the groups.

Looking at the re-watch variables, the 4 groups emerged. The first group would re-watch the video right away, but rarely if ever re-watched the video after that. The second group didn't re-watch the video right away, but would re-watch the video later. The third group re-watched right away and re-watched again later. The final group rarely re-watched any videos. Table 6 shows the distribution of the groups and their mean values for the two re-watch variables and the percentage of videos watched overall.

Table 6. Group Distributions

Group	N	Mean % of videos Re-watched right away	Mean % of videos Re-watched later	Mean % of videos watched overall
Only re-watch right away	4	67.5	7.5	85
Only re-watch later	11	11	50	77
Re-watch now and later	9	66	68	90
Don't re-watch	6	8.33	5	68

Using these 4 groups an ANOVA was run against the other questions on the survey. Only two questions showed a significance level less than .05. A Tukey analysis was run on these two questions. For the following variable, "Overall the videos have been helpful in my learning Python." There were significant differences (p = .041) between the "Don't re-watch" group and the "Re-watch now and later" group. Similar results were found (p=005) for the variable "Even if I had the instruction in person, the videos would be helpful?".

Digging deeper it is interesting to see that the "Don't re-watch" group still have a mean value of 4, Agree, for the question, "Overall the videos have been helpful in my learning Python." That group had a mean value of 3.66 which was almost Neutral, for the question, "Even if I had the instruction in person, the videos would be helpful?". The students who watched both now and later had means of 4.77 and 4.88 for those two questions, clearly the "Don't re-watch" group felt the videos were less useful.

Still, it appears that engagement in the videos did not reflect many differences in how the students perceived or used the videos in the course.

RQ 4 How do students' preference for online instruction influence their video usage and perceptions in an online programming course.

As noted earlier the students reported that they would have preferred the instruction in-person. On the question, "I would prefer to have the instruction in person rather than on video" the students reported Neutral (N=9), Agree (N=11) and Strongly Agree (N=10). Using theses three groups an ANOVA was run with the variables on the survey. Only one variable showed a significant result (p=.021). A Tukey analysis was run to determine which groups differed on that question, "What percentage of the videos have you completed watching?". The two groups that differed were the "Neutral" and "Agree" groups. Not surprisingly, the highest mean score (94.22% videos completed) for that variable was in the "Neutral" group and the lowest mean (69.22% videos completed) was in the "Agree" group. It is not surprising that students who had signed up for an in person class but received an online class had different values for this variable, but what is surprising is that no other variable showed any significant differences.

CONCLUSION

Utilizing videos that were produced using the techniques in video development from the Cognitive Theory of Multimedia Learning was shown to allow student satisfaction in learning Python programming. This was true for a group of students who would have preferred in-class learning. The students reported this to be especially helpful in completing the homework. They also expressed the view that the videos would be helpful in an in-person class as well. Clear groups could be found by looking at the frequency and timing of re-watching the videos from the course. With minor exceptions, no real differences were found in the students' perceptions of use of the videos in the class based on the engagement or desire to have an in-person class.

For RQ 1, "What are students' views on using video tutorials to learn Python?" all of the scores were positive to very positive.

For RQ 2. "How do student use the tutorial videos to meet the different learning objects in an online programming course?" student overwhelming (96%) use the videos to help with the homework and the majority (875) either prefer or strongly prefer having new topics explained using video.

For RQ 3, "What are the differences in video usage and perceptions between students of different engagement levels in a programming course?" it was clear there were four distinct groups based on the student's use of the videos and when they re-watch the videos, but only minor videos were found between those groups.

For RQ 4, "How do students' preference for online instruction influence their video usage and perceptions in an online programming course." Students who preferred having online instruction completed watching a significantly larger number of videos (94.22% videos completed) than those didn't prefer online instruction (69.22% videos completed).

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