10th International Conference on Higher Education Advances (HEAd'24)
Universitat Politècnica de València, València, 2024
DOI: https://doi.org/10.4995/HEAd24.2024.17212

Interactive videos: its effect on cognitive load and students' preferences across modes

Corlia Joynt
Department of Accounting, University of Pretoria, South Africa.

How to cite: Joynt, C. 2024. Interactive video: its effect on cognitive load and students' preferences across modes. In: 10th International Conference on Higher Education Advances (HEAd'24). Valencia, 18-21 June 2024. https://doi.org/10.4995/HEAd24.2024.17212

Abstract

This study aimed to investigate the impact of interactive videos on cognitive load, in specific extraneous load, which plays a crucial role in instructional design. Extraneous load is the cognitive burden imposed by the design and dissemination of educational material, potentially hindering optimal and efficient learning. The study examined the effects of interactive videos by having students complete five formative assessments using both linear (traditional) and interactive videos in a rotational manner. Analytical strategies, including cross-over repeated measures ANOVA and independent samples t-tests, were employed. The results revealed a statistically significant difference in extraneous load scores between the two modes, although this effect diminished over time. Based on the findings, it is recommended that educators provide students with multiple opportunities to acclimate to interactive videos over an extended period. Additionally, student preferences favored interactive videos, and this inclination strengthened with increased exposure.

Keywords: *cognitive load; extraneous load; interactive videos; accounting education; cross over repeated measures;.*

1. Introduction

The use of videos in education has enjoyed popularity as a mode of delivery and the pandemic necessitated the implementation of various digital enhancements to current online offerings. During the pandemic, lecturers explored the use of new software (H5P) and consequently the linear (traditional) video, was replaced by interactive videos (also known as in-video assessments). Interactive videos is a relatively new addition to software available on the learning management systems (for example BlackBoard) and was developed by H5P.com. This software enables educators to convert any linear (traditional) video (self-created or from platforms such as YouTube) to an interactive digital video as a formative assessment tool. Interactive videos use the same video content as the linear video, but instead of answering the questions <u>after</u>

watching the video, students respond to questions (in the form of questions, quizzes and polls) while watching the video. The video pauses as soon as a question is posed and students need to answer the question before the video proceeds.

Numerous studies have been conducted on the use of interactive videos in a variety of disciplines. Reports include an improvement in academic performance, student motivation and engagement (D'Aquila, Wang & Mattia, 2019), better retention of knowledge and higher level of understanding (Hung & Chen, 2018) and the reported increase of self-directed learning as interactive videos are appealing to students (Bétrancourt & Benetos, 2018). However, the effect, if any, on cognitive load has not been investigated thus far.

Why is understanding cognitive load crucial in an education setting? The goal of learning is essentially the retention of knowledge to attain mastery through the development of schema. Schema construction and automation are processes that take place in the long-term memory of a person. However, before it can reach this stage, it needs to be extracted from working memory. Cognitive load theory focuses on increasing the learning efficiency of complex tasks. This means that the least amount of effort should be expended by a student to optimize working memory and comprehend content (Mostyn, 2012). Therefore, the effect on working memory should be a consideration for all educators who wish to develop learning material (Paas et al., 2003) as the instructional control of cognitive load can influence the learning experience.

Cognitive load represents the load on a human's cognitive system when performing a particular task. Cognitive load includes three different types of cognitive processes during learning: (i) *intrinsic* cognitive load that is influenced by the subject matter (or discipline) and difficulty of the task; (ii) *extraneous* load that is influenced by how well or poorly the material is designed and (iii) *germane* load that is influenced by problem-solving skills, analysis, and interpretation of subject matter (Sweller, van Merrienboer & Paas, 1998). In essence, educators should aim to develop material that will not overextend extraneous load so that sufficient working memory is available to expend on intrinsic and germane load (Kruger & Doherty, 2016).

Although a number of studies were conducted to report on the effect of linear videos on cognitive load (Chen & Wu, 2015; Kruger & Doherty, 2016; Alemdag, 2022), research on the effect of interactive videos on cognitive load of introductory accounting students has not been conducted. Since it was reported that the use of videos to teach complex concepts may increase cognitive load and negatively affect learning outcomes, it is important from an instructional design perspective, to be cognisant of the possible impact of the mode of delivery, especially on novice accounting students. Given the absence of adequate research, the following specific research question is addressed:

RQ1: Is there an effect on cognitive load when interactive videos are used as formative assessments of introductory accounting students?

Regardless of the effect on cognitive load, student motivation and the learning experience might be influenced by the mode of delivery. This study examined the preference of students by posing the following question:

RQ2: Which mode of assessment (linear video vs interactive video) do students prefer?

2. Literature review

2.1. Linear vs interactive videos

The advantages of using videos include accessibility of material, display control, shareability and the benefit of being able to watch the video more than once if needed (Afify, 2020). Interactive videos differ from linear videos as interactive videos include features that demand engagement from students in activities and its content (Shelton, Warren & Archambault, 2016). Characteristics of interactive videos include the segmentation of content; interactivity by means of embedded questions and assurance of completion as the settings allow instructors to decide whether the video can be skipped ahead or not. It also provides an opportunity for immediate feedback after a question was answered and this allows for consistent evaluation of knowledge transfer as the content is delivered.

2.2. Prior literature on the effect of videos on cognitive load

Multimedia instruction (such as the use of educational videos) requires total processing capacity in the form of essential processing, incidental processing and representational holding (Mayer & Morena, 2003). This means that on-screen texts, illustrations, animation, sounds and narrations might all add to cognitive load. Literature on the effect on cognitive load imposed by linear and interactive videos are limited, but available studies reported that the length of the video (measured in minutes) influenced cognitive load (Afify, 2020) – videos less than 6 minutes long imposed the least amount of cognitive load in an extraneous form on students and maximised their germane load. Research in accounting is severely limited with discussions on why the effect on cognitive load should be considered (Mostyn, 2012) as well as mentioning cognitive load, but not reporting on the effect of linear videos on cognitive load of accounting students (D'Aquila, Wang & Mattia, 2019).

3. Research methodology

3.1. Study design

First-year students in introductory accounting are required to complete formative assessments in the form of pre-class activities in preparation of a new topic. The student cohort (n=956) was randomly divided into two groups (Groups 1 and 2) and students could not migrate between groups. Neither could they choose between linear or interactive videos for a particular test.

The quasi-experiment started with group 1 receiving the treatment (watching the interactive video - IV) and group 2 being the control group who watched the linear video (L) and answering the questions thereafter. The control group and treatment group alternated between receiving the treatment (interactive video) and being the control group (linear video). Therefore, each student were exposed to both modes.

The treatment and the control group watched the same videos and answered the same questions, but the format of the formative assessment was different. Both groups completed a total of five tests over the course of the first eight weeks of the semester.

Table 1. Experimental design (IV = Interactive video and L = Linear video)

	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Group 1	IV (n=217)	L (n=156)	IV (n=207)	L (n=161)	IV (n=232)
Group 2	L (n=162)	IV (n=245)	L (n=202)	IV (n=183)	L (n=189)
N	379	401	409	344	421

To measure the effect on cognitive load (CL), students were asked to complete questions on CL using an instrument developed by Leppink, Paas, Van der Vleuten, Van Gog and Van Merriënboer (Leppink et al., 2013).

3.2. Methodology and analysis

A quantitative research design is followed. Initial analyses were conducted using cross over repeated measures ANOVA and independent samples t-tests. Thereafter paired samples t-test were conducted to explore the drivers of significance between the treatments.

To determine the preference of students, students were asked to choose their preferred mode after tests 2 and 5 by choosing “A. Interactive videos / B. Linear videos / C. No preference”. The responses were grouped and calculated as a percentage of responses.

3.3. Sample selection

The sample comprised students enrolled for introductory accounting, but not necessarily studying towards a professional qualification in accounting. Participation in the experiment was voluntary (i.e. completion of the CL instrument), although completing the assessments counted for marks as per the usual weighting.

4. Results

4.1. Descriptive statistics

Formative assessments were made available to all students enrolled for the course, but not all students completed every formative assessment. Of the cohort of students, 636 students wrote one or more test, but only 199 students completed all five tests. Of these students, 174 completed all five tests as well as the instrument to measure cognitive load. Of this sample, 65% were female students. Students in the sample ranged between 18 and 21 years of age. No data was collected to depict ethnic heritage or home language. However, since these tests were open to all students in more or less two week intervals, the number of students who participated and completed the instrument varies. Refer to table 1 for the sample size per test.

4.2. Instrument validity

Although a tested instrument was used to evaluate the level of cognitive load (Leppink et al., 2013), factor analysis was conducted and repeated for all five tests. The same result was obtained in each instance: there is a strong internal consistency ($\alpha>0.7$) and confidence that constructs are reliably measured. Factors were 'Intrinsic Load"(IL), "Extraneous Load"(EL) and "Germane load"(GL).

4.3. Cross over repeated measures ANOVA

The purpose of cross over repeated measures ANOVA is to determine the effects of two or more treatments on the same set of students. This analysis is also fit to assess the effect of treatments over time. Table 2 summarises the results and indicates that a significant difference between EL scores for test 2 was observed ($p<0.001$).

Table 2. Results from the cross over repeated measures analysis per construct

	Test 1	Test 2	Test 3	Test 4	Test 5
Group 1	IV	L	IV	L	IV
Group 2	L	IV	L	IV	L
IL (Sig.)	.573	.310	.551	. 105	.337
EL (Sig.)	.102	**<.001***	.253	.864	.230
GL (Sig.)	.673	.365	.862	.782	.605

(IL = Instrinsic load; EL = Extraneous load; GL = Germane load)

4.4. Independent samples t-test

An independent samples t-test was conducted to compare the means of two groups in order to determine any significant differences in the means. Table 3 shows the results of cognitive load when comparing groups who wrote the same test. Test 2's results were significant at a 1% confidence interval. None of the other results were signinifantly different between groups.

Table 3. Results from the independent samples t-test

	Test 1	Test 2	Test 3	Test 4	Test 5
Group 1	IV	L	IV	L	IV
Group 2	L	IV	L	IV	L
IL (Sig.)	.299	.002	.961	.545	.105
EL (Sig.)	.967	**<.001***	.502	.321	.782
GL (Sig.)	.410	.003	.055	.902	.987

4.5. Paired sample t-test

The paired samples-test was used to determine whether there is a significant difference in means between tests of the same student. After test 2, all students had exposure to the linear videos as well as the interactive videos. Based on results from the previous tests, it was clear that a significant difference exists between test 1 and test 2 for the extraneous load (EL). The question remained: which one of these modes (linear or interactive video) was driving the significance?

Means derived from the paired samples t-test were used to address that question and these are shown in tables 4 and 5.

Table 4. Results from the paired sample t-test

	N	Correlation	Significance (Two sided *p*)
Pair 1 IL (IV) & IL (L)	174	.294	<.001
Pair 2 EL (IV) & EL (L)	174	.362	<.001
Pair 3 GL (IV) & GL (L)	174	.168	.027

Table 5. Means per cognitive load construct

	Test 1	**Test 2**	**Means IL**	**Means EL**
Group 1	IV	L	IV = 12.34	IV = 11.21
Group 2	L	IV	L = 8.43	L = 6.84

4.6. Students' preferences

Students were asked to choose their preferred mode of educational delivery. Table 6 shows their choices and how it changed from test 2 to test 5.

Table 6. Students' preferences

	Interactive video	Linear video	No preference	No response
After test 2	57%	22%	15%	6%
After test 5	61%	16%	19%	4%

5. Findings

Evidence in support of an initial impact on extraneous load was reported. Following test 2, all students experienced both forms of tests and a significant difference ($p<0.001$) in extraneous load was observed. A means comparison indicated that the interactive videos were driving the significance in cognitive load differences, but that this difference eroded over time.

This initial cognitive overload which erodes over time, is supported by theories underlying the split attention effect (Kalyuga, Chandler & Sweller, 1999). Initially students are unfamiliar with the mode and how it works, but over time, this is mitigated and students experience the same cognitive efforts regardless of the delivery mode.

It is therefore recommended to use interactive videos over an extended period of time so that students can become familiar with it. If these videos are used for formative assessments, it is also recommended that students are offered more than one attempt initially to foster familiarity with the mode.

Student preferences changed slightly over the period to favour interactive videos (see Table 6). Preference influences motivation to learn and improves the learning experience of students. It is important to note that the length of the video might negatively impact the learning experience and enjoyment regardless of the format (linear or interactive), therefore all videos (regardless of mode) should be 6 minutes or shorter to achieve optimal engagement and academic interaction.

Limitations of this study included the use of only introductory accounting students from one cohort. It is recommened that this study be repeated across various disciplines to determine the effect of interactive videos on cognitive load. Although the more these tests included a mix of difficult and moderately difficulty topics, it is possible that the level of difficulty of a topic might influence cognitive load. It is recommended that future analyses incorporate a control variable to mitigate the effect of understandability of a topic.

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