Investigating interactivity in instructional video tutorials for an undergraduate informatics course

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The aim of this study is to investigate the impact of interactive and demonstration (non-interactive) video tutorials for software training on the effectiveness of procedural learning and student satisfaction. An analysis of signalling made by instructional designers was carried out to develop high-quality instructional video materials. These attention cues could be used in both demonstration and interactive video tutorials to enhance the acquisition of procedural knowledge. Both types of video tutorials had a positive effect on the learning process, and students achieved very good learning outcomes. Students who used interactive videos achieved slightly better learning outcomes. The study revealed higher satisfaction with interactive videos which were perceived as more instructive compared to the demonstration videos.

Introduction

The development of multimedia and information communication technologies (ICTs) such as virtual workspaces or massive open online courses (MOOCs) creates new environments for teaching and learning. Accordingly, new areas of research are being developed as well. Video is one of the instructional media used in such environments. Compared to the static content, video is a medium that effectively engages the audience; it provides a multi-sensory learning environment and serves to present information attractively, with the aim of enabling better information retention (Whitney & Dallas, 2019).

In recent years, we have witnessed that many software companies, online education companies and educational institutions began to produce demonstration video tutorials and there is a continuous surge of popularity of instructional videos, compared to paper tutorials. Demonstration videos are the prevalent format of instructional videos in software training, consisting of a screen capture animation accompanied by narration (van der Meij & van der Meij, 2013, p. 210). Software training in a video-driven learning environment aims to help students develop procedural knowledge described as "know-how", i.e. mastering a method or a skill and is formed by doing (Anderson, 1983). In software training students need to learn a sequence of activities performing a series of actions that lead to software task completion (van der Meij & van der Meij, 2016, p. 528). On the other hand, declarative knowledge is described as "know-that", i.e. mastering of facts, theories and concepts. The instructional videos in our study aimed to enhance procedural knowledge, due to their task-dependent nature.

Apart from demonstration video tutorials, interactive videos are rapidly gaining popularity. "Because of the added dimension that video offers, interactive video tutorial surpasses other computer-based tutorials, based on its ability to involve the learner and engage him or her in a two-way dialog" (Kwame, Dzegblor & Lodonu, 2015, p.210). Unfortunately, there is very little literature investigating video-based software training and little is known about the effects of demonstration videos on the learner's performance. Also, the existing empirical results that compare demonstration video and paper-based tutorials for software training are quite inconclusive. While the study by Mestre (2012) revealed that students prefer a text over video tutorials, several other studies indicated that learners favour video over text tutorials (Lloyd & Robertson, 2012; van der Meij & van der Meij, 2016), while Käfer, Kulesz and Wagner (2016) detected no clear preference for static text or non-interactive video tutorials. Regarding academic performance, Palmiter and Elkerton (1993) reported that during training demonstration video users were faster and more accurate than text-only users, but only 7 days later there was no difference between users in terms of the measured procedural knowledge. Other studies could not find a statistically significant difference with respect to academic performance between text and video tutorials (Alexander, 2013; DeVaney, 2009). It is important to mention that instructional design of videos in these studies (i.e. how the information is structured and how the learning goals are achieved) was not described in detail.

As to instructional design of demonstration videos, a combination of multimedia learning and demonstration-based training has recently been used (Brar & van der Meij, 2017; van der Meij & van der Meij, 2016). But, results of the empirical studies have shown that although demonstration videos designed in this way enhance learners' motivation and significantly raise learners' task performance (during which a learner can consult the video), learning from these videos (tested when a learner can no longer consult the video) is lagging behind (van der Meij & van der Meij, 2016). Also, empirical research on cueing has reported that successful foundations for attention do not necessarily produce more efficient learning (Kriz & Hegarty, 2007; Skuballa, Schwonke & Renkl, 2012), which triggered our need for research on other activities involved in software training, i.e. the learner's retention, (re)production and satisfaction.

The prior work mostly investigated the effects of demonstration videos or animations on the learning performance or learners' satisfaction, compared to paper-based and digital text. Strecker, Kundisch, Lehner, Leimeister and Schubert (2018) identified a gap in the research about the influence of interactive videos on the learning performance, or about the other effects of interactive videos in an educational context. Only Kwame et al. (2015) have presented information about student perceptions regarding interactive videos, while only one recent study (Keller, Langbauer, Fritsch & Lehner, 2019) reported a significant positive effect of interactive video on learning quality and user perception compared to PDF manuals.

Therefore, we focused on assessing the impact of interactive video tutorials on learning effectiveness and student satisfaction. Furthermore, an analysis of attention cues made by instructional designers in both demonstration and interactive videos was carried out to develop guidelines for high-quality instructional video materials.

Literature review

Instructional video design

The use of instructional video has become an important part of modern educational systems (Giannakos, 2013; Kleftodimos & Evangelidis, 2016), but the research about its impact on the educational success of learners has been characterised by a high degree of inconsistency in findings. Höffler and Leutner (2007) conducted a meta-analysis of 26 research papers published between 1973 and 2003, comparing instructional animations (videos, computer animations) and static tutorials based on images from biology, physics, chemistry, math, etc. The advantage of instructional animation was determined only under certain conditions, with the key factors being the acquisition of procedural and motor skills and representational animations where the animated steps were in explicit relation to the content the learners needed to adopt. Some studies (Choi & Yang, 2011; Lloyd & Robertson, 2012) found that demonstration videos were more effective than text for problem-based instruction. Other studies that compared a demonstration video with print tutorials for undergraduate students detected no advantage of video for learning accounting concepts (Beitzel & Derry, 2009), for computer tasks (Alexander, 2013) or for acquiring science concepts (Stice, Stice & Albrecht, 2015).

Although experiments on instructional videos have produced mixed results, thirty years of research on design of online instruction techniques has yielded research-based design principles that contribute both to the science of learning and to the science of instruction (Kalyuga & Sweller, 2014; Mayer & Fiorella, 2014; Mayer, 2018; van Gog, 2014).

Multimedia instructional design

The theory and practice of multimedia instructional design has been used for the past few decades and several authors have proposed design recommendations for instructional video tutorials (Bétrancourt & Benetos, 2018; Mayer, 2014; van der Meij & van der Meij, 2013). Mayer (2017) described research-based principles for designing multimedia instructional materials to promote academic learning. The principles relevant for our study are:

- coherence principle which states that students learn better when extraneous material is eliminated (Mayer, 2017, p. 407);
- signalling principle which involves highlighting essential material (Mayer, 2017, p. 407);
- redundancy principle which suggests using narrated graphics without adding on-screen text material (Mayer, 2017, p. 408);
- spatial contiguity principle which dictates that printed words should appear near the corresponding graphics (Mayer, 2017, p. 410);
- segmenting principle which suggests breaking a lesson into smaller segments terms (Mayer, 2017, p. 411);
- pre-training principle which requires that designers provide pre-training in key terms (Mayer, 2017, p. 412);

- modality principle which states that spoken text should rather be used with graphics than printed text (Mayer, 2017, p. 413); and
- voice principle which requires the narrations in appealing human voice (Mayer, 2017, p. 414).

According to van der Meij and van der Meij (2013, p.207), the instructional designer could use eight guidelines to design videos specifically for software training:

- provide easy access;
- use animation with narration;
- enable functional interactivity;
- preview the task;
- provide procedural rather than conceptual information;
- make tasks clear and simple;
- keep the video short; and
- strengthen demonstration with practice.

To accommodate the learner's interaction with the environment in the most effective way, it is important to use spatial attention cueing (signalling) that has been shown to reduce cognitive load, guide the learner's attention and foster learning (Boucheix & Lowe, 2010; Mayer & Fiorella, 2014; van Gog, 2014), especially for learners with low to medium prior-knowledge (Richter, Scheiter & Eitel, 2016).

The signalling principle (Mayer, 2005, p. 183) states that humans learn better when attention cues are added to the essential material, since they highlight the organisation of the material. Signalling refers to the use of colour, italic or bold letters to highlight a printed text, pointing arrows, circling, underlining, flashing and spotlighting or colour to highlight a graphic without altering the content and to help learners to integrate information into a coherent mental representation (van Gog, 2014).

According to van Gog (2014), signalling allows learners to achieve better learning outcomes, as it helps learners to use their own limited working memory in an optimum way. According to the signalling principle, learners, lacking proper signalling, possess fewer resources in the working memory. Signalling allows greater visual search efficiency. This leaves learners more time to think about the key concepts needed to understand the presented material (Ozcelik, Arslan-Ari & Cagiltay, 2010).

Interactive video tutorials

An interactive video is a video built to enable engagement beyond viewing. There are different definitions of interactive video. Zhang, Zhou, Briggs and Nunamaker (2006) believed that interactive video attracts students' attention to educational material, thanks to the interactivity that occurs between the individual and the video material. Chen (2012) described interactive video as one of the most exciting types of media that combines the power of moving images, the video story, depth and richness of information, all enriched with interactivity.

Interactive video enables engagement, participation, responsiveness, and active engagement of students. It allows students to pay full attention to educational material through active interaction (Zhang et al., 2006). Aladé, Lauricella, Beaudoin-Ryan and Wartella (2016) defined interactivity as a form that invites users to physically manipulate the platform to improve learning activity. Chambel, Zahn and Finke (2004) stated that interactivity within a video allows users flexibility, control, autonomy, and motivation. According to some research findings (Kolås, 2015; Onah, Sinclair & Boyatt, 2014), interactive video could be used in massive open online courses (MOOCs) to engage and motivate users and to improve their learning.

Jensen (2008) claimed that linear (demonstration) video promotes apathy among learners rather than stimulating their activity, leaving a student as a passive observer. On the other hand, interactive video engages learners through their interaction with the instructional material (Kolås, 2015). Interaction is considered desirable because it encourages active learning. Therefore, interactive video is increasingly being used for educational purposes to increase learners' engagement, interest in course material, motivation, satisfaction and learning efficiency (Mayer, 2014; Zhang et al., 2006).

MOOCs provide a variety of options for implementing interactive video tutorials that can have a positive impact on interest and motivation for online learning, greater engagement and student persistence to complete the course. Although there are many tools for creating interactive videos (e.g. Camtasia, Panopto, EDpuzzle, Thinglink, H5P, Playposit, Viddler, Uscreen, Vidgrid, HapYak, Verse, RaptMedia, Klynt, Koantic, Arc Media, HiHaHo Vidversity, etc.), the application of interactive video within the educational process is still not sufficiently explored. According to Kolås (2015), the reason for this is that teachers do not have access to tools or knowledge of instructional design to be able to implement interactivity within videos.

As we mentioned before, experiments on demonstration video tutorials for procedural knowledge development are rare, but existing. However, there is a gap in the research about the influence of interactive videos on learning performance and learner satisfaction compared to demonstration videos.

Zhang et al. (2006) have researched the level of learner satisfaction in using interactive educational video material. The results of the research showed that the learners who were learning using interactive video tutorials had a higher level of satisfaction than those who were taught without video aids. They have concluded that videos can increase the focus on the subject of lectures, with a positive effect on student satisfaction.

Some authors have investigated interactivity in tutorials for undergraduate physics students (Singh, 2004), but the interaction was either not part of the video (the linear video was part of a web environment which included video, audio, and cursor movement to scaffold student learning), or interaction was embedded in a video as quiz questions (Ketsman, Daher & Colon Santana, 2018). The latter article showed no statistical significance in learners' performance when the experimental group (that learned from videos with embedded quiz questions) and the control group (that learned from linear videos and answered the quiz questions afterward) were compared. However, qualitative analysis revealed strong learners' preferences toward the use of video with embedded quizzes.

Finally, Kwame et al. (2015) reported that 68% of their learners found the interactive video tutorials either excellent or very good, when asked about how instructive those tutorials were for software learning, though the influence on learning outcomes was not measured.

Research questions

The following research questions were addressed:

1. Do interactive video tutorials for software training lead to better procedural knowledge results, compared to the demonstration instructional video tutorials?
2. Is there a difference between the two experimental conditions (interactive vs. demonstration) concerning student satisfaction?

Method

Participants

At the beginning of the study 110 undergraduate informatics students were asked to answer demographic questions and to self-assess their MS *Word* skills on a Likert scale with categories "Poor", "Average", "Good" and "Excellent". Only students who reported "Average" MS *Word* skills were invited to continue in the study, with 52 students meeting this condition. Thus, a convenience sample of students (N=52) was obtained for assignment into two groups, one group being provided with demonstration video, while the other group learned with interactive video. Of the respondents, 29% were female and 71% were male students; all were 21-23 years of age and at the undergraduate level of study. Both groups of students, demonstration and interactive, reported no previous experience with video lectures.

Therefore, we assumed homogeneity of skills and characteristics of students between the two groups. The learners were provided with two different video conditions containing the same learning content. All instructional materials were in Croatian, while the software was in English.

Instructional materials

The instructional video tutorials, about around four minutes in duration, were designed to teach formatting in Microsoft *Word 2010* and were divided into four chapters to allow a meaningful segmentation of tasks. They were designed as a demonstration of actions; a sequence of actions was recorded with the corresponding voice instructions. All four tasks were anchored in the task domain of students since they need to learn formatting in

Microsoft *Word* to be able to write their seminar papers and a bachelor thesis. Scripting and testing of the demonstration videos were performed during an academic year as part of the research comparing static and dynamic educational resources (Kisicek & Lauc, 2015), while the work continued with interactive videos during the next year.

Compared with other kinds of delivery that can attain the same learning outcomes and student satisfaction, such videos are a sufficiently worthwhile allocation of staff resources in introductory informatics courses with large number of students. The cost benefit of these videos might be attractive to teachers who must repeatedly give the same tutorials to undergraduate students, since such videos might save their time, allocation and utilisation of university space, and teacher efforts.

This is the list of chapters in both type of video tutorials (demonstration and interactive):

- Chapter 1: Creating templates and organisation of Styles in MS Word
- Chapter 2: Generating a table of contents in MS Word using styles (not built-in)
- Chapter 3: Using commands for searching and replacing content in MS Word
- Chapter 4: Regular expressions in MS Word

Examples of interactive videos in English and Croatian are available at:
http://inf.ffzg.unizg.hr/images/Styles_in_Word_interactive_En.swf
http://inf.ffzg.unizg.hr/images/Styles_in_Word_interactive_Cro.swf

An example of a demonstration video in Croatian is available at:
http://inf.ffzg.unizg.hr/images/Styles_in_Word_Cro.swf

Students using demonstration video tutorials were required to watch the recorded videos. Students using interactive video tutorials had to click on the required part of the window at a certain point of the tutorial or they had to type in the required content to continue with the video tutorial. At the beginning of each interactive video chapter, students were instructed that the video would stop at each important new step until they performed the required action. Both groups of students were given a choice to turn on or off a textual explanation (subtitles) and spoken explanations during the video, to ensure that subtitles or audio are not redundant.

In addition, students also had the following options: to rewind the video, pause it, play it back and play it forward so that they could adapt their interaction with videos according to the subjective (perceived) difficulty of the chapter, their own abilities or their own learning strategies.

Signalling in the instructive video tutorial

Signalling in interactive video tutorials

1. The user must click on a specific part of the window within the video to perform the action specified by the female speaker. The signalling is time-bound with speech so

that video is paused until a learner clicks on the highlighted part of the MS *Word* window. Signalling is a combination of:

- a rectangular frame with a thicker red border and a slightly shaded filling added to the parts of the MS *Word* window which is displayed when these parts are mentioned in the speech; and
- textual instructions to a learner written in white letters on the red background of the rounded rectangle which appears at the time that the same instruction is mentioned in the speech (Figure 1).

These signals are meant to boost processing efficiency and help a learner to achieve better integration of new content.

If a learner incorrectly clicks on another part of the window (despite the instructions), a large red "X" appears in the video and the video remains paused (Figure 2).

Figure 1: Textual instruction that requires learner interaction with content through clicks

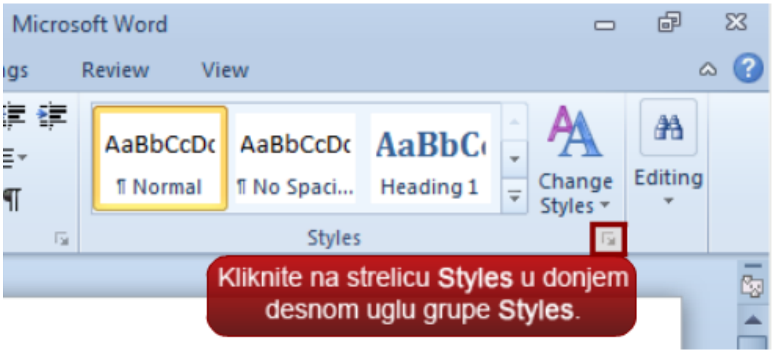
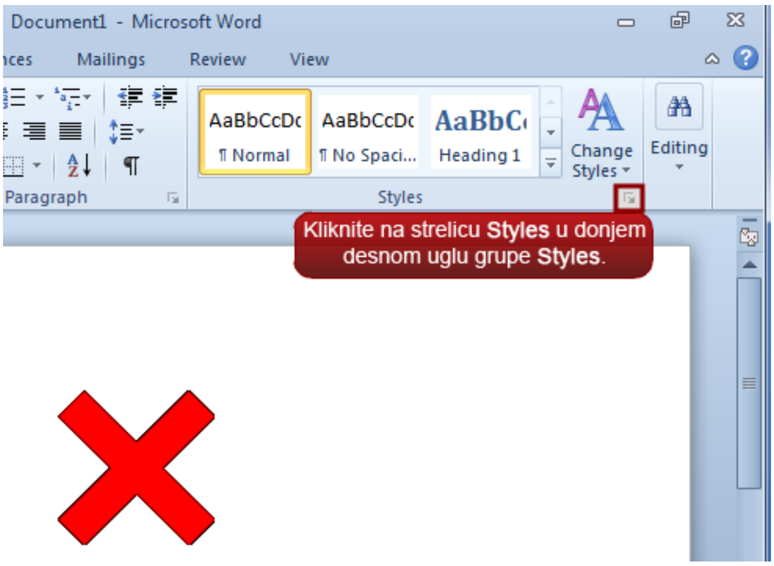
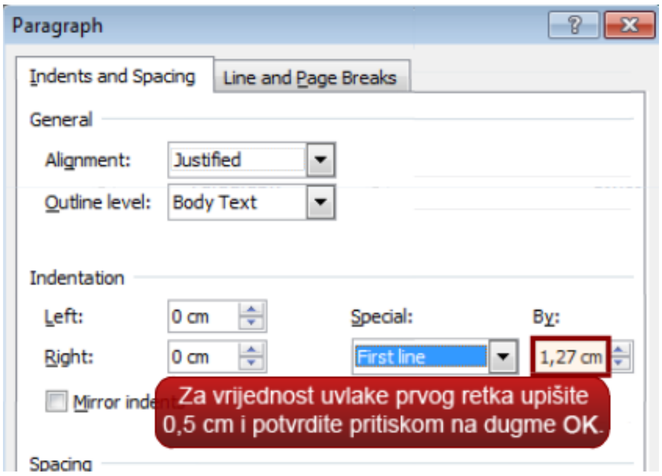


Figure 2: Signal for the incorrect mouse click



2. The user must type in the required content in the specified space within the window of the video. It is synchronised with speech so that the video is paused until a learner enters the required content. Signalling is a combination of:
   - a rectangular frame with a thicker red border and a slightly shaded filling added to the parts of the MS *Word* window which is displayed when these parts are mentioned in the speech; and
   - textual instructions to a learner written in white letters on the red background of the rounded rectangle which appears at the time that the same instruction is mentioned in the speech (Figure 3).

Figure 3: Textual instruction that requires learner interaction with content through textual input



If a learner types in the incorrect text, a large red "X" appears in the video and the video remains paused (Figure 4).

Signalling in demonstration video tutorials

1. Shading and frames - red rectangular frames are used to mark the location where a learner needs to click to perform the action that is mentioned in the speech during the video. For example, a voice instruction says: "Open a new *Word* document" and a procedure is displayed in the video using the signalling to indicate all the window parts that need to be clicked on to complete the action (Figure 5).

2. Sound signalisation simulating typing of text within the MS *Word* dialog box to perform a part of the learning activity. Figure 6 shows the process of entering the word "Glavni (eng. Main)" in the text box "Name:", when typing a word in a video is accompanied by a typing sound.

3. Each mouse-click shown in the video is signaled with a small blue square. It appears next to the mouse arrow simultaneously to a mouse-click in a video (Figure 7).

Figure 4: Signal for the incorrect text

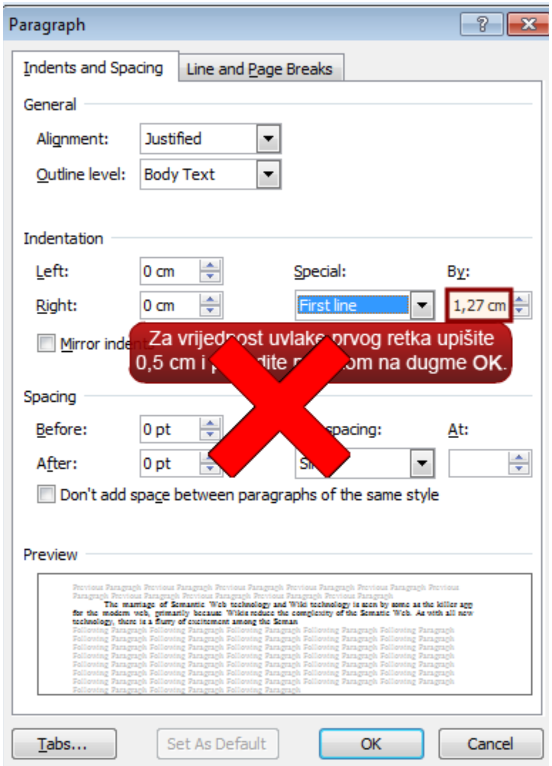


Figure 5: Signalling using shading and frames

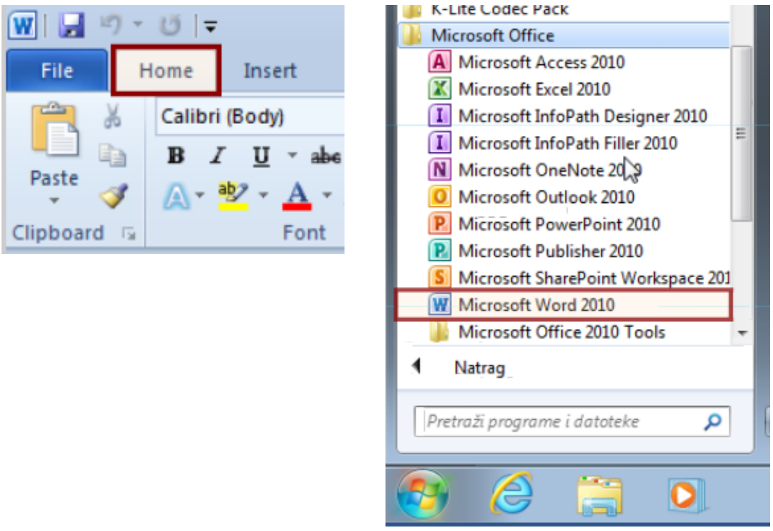


Figure 6: Text typing accompanied by a sound signal

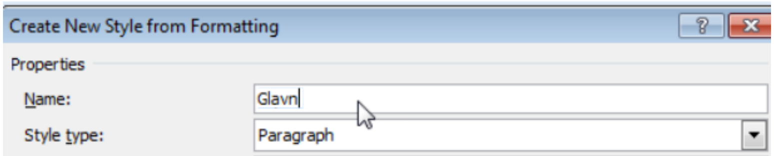
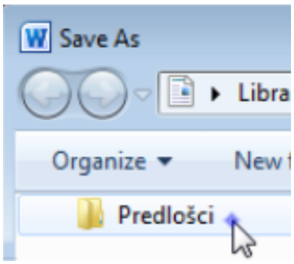


Figure 7: Mouse click signalled with a small blue square



4. The topics of the video tutorial are displayed as a full-screen image when the topic is mentioned in the video speech. In other words, the beginning of each chapter is indicated with a label (see Figure 8) which is meant to serve as an organiser that facilitates the construction of the mental model.

Figure 8: A label indicating the beginning of a chapter

Instruments

An initial questionnaire was used to collect demographic data and self-perceived level of skills in using MS *Word*, to determine the student's eligibility to participate in the study.

Two tests (pre-test and immediate post-test) assessed procedural learning before and after each video chapter. The test items in all four pre- and post-tests presented formatting tasks in MS *Word 2010* that were similar to tasks in both demonstration and interactive videos. The test items in pre-tests and post-tests were different but included the same content. For each formatting task, a rating scheme with all the necessary steps to be taken to solve the problem was created.

The final satisfaction questionnaire was administered as paper-and-pencil instrument where respondents have rated how instructive each video tutorial was on a 5-point Likert scale ranging from poor (1) to excellent (5).

Procedure

The experiment was conducted in five sessions that took place in the computer room of the Polytechnic of Rijeka, Croatia. During the first session, the students had to complete a demographic survey and a survey about the self-perceived level of skills in using MS *Word*. Out of 110 participants, only 52 students who reported "Average" MS *Word* skills participated in the subsequent sessions.

Each session began with a short introduction, after which the pre-test was administered (15 minutes). Then, students worked individually with content-equivalent resources in the form of demonstration and interactive videos on a personal computer equipped with MS *Word* 2010 and headphones. Students could choose to watch videos (a) with subtitles, but without voice instructions, (b) with both subtitles and voice instructions, (c) with voice instructions only or (d) without subtitles and without voice instructions.

After each video, students had to complete the immediate post-test (15 min) to gain insight into possible differences in procedural knowledge outcomes with regard to the type of video material. Finally, the satisfaction questionnaire was administered.

Results

We hypothesised that, compared to the demonstration video, interactive video will improve the learning and satisfaction of learners. Starting from the assumption that students will be more satisfied if the instructional strategy helps them to learn more effectively, we encompassed both the effectiveness of video chapters and learners' satisfaction by measuring how much each video chapter was instructive.

Instructiveness was measured through the survey question on a 5-point Likert scale and presented through the dependent variable “instructive”. Thus, comparing two instructional modalities, interactive and demonstration, we hypothesised that interactive video is more instructive, providing the learning content in a more useful and informative way, as observed through students' satisfaction expressed on a 5-point Likert scale. We also hypothesised that interactive video enhances learning effectiveness, as observed through students’ test scores.

Research question 1

The data obtained from the pre- and post-tests show that in the procedural learning environment students who use interactive instructional videos based on multimedia principles achieve somewhat better results, compared to learners using demonstration video tutorials, even though there was no statistical significance.

According to Zhang (2006, p.20), "the higher degree of control in interactive video can positively influence the effectiveness of knowledge transfer and lead to higher self-satisfaction of learners". So, our assumption was that learners will be more satisfied if the instructional strategy has helped them to learn more effectively.

Research question 2

The data obtained from the pre- and post-tests supports the thesis that if perceived student satisfaction is expressed through instructiveness, students who use interactive video are more satisfied than those using demonstration video. It can be concluded that the perception of instructiveness in the interactive group was statistically significantly higher compared to the demonstration group (Mann-Whitney, U=208.5, p=.018, sig≤.05, 2-tailed). As shown in Table 1, subjects participated in the study belonged to one of two groups with the different treatment assigned to a group.

Table 1: Groups and treatments (N=52)

Group	Learning environment	Group size (n)
1	Demonstration instructional video	24
2	Interactive instructional video	28

A composite variable containing pre-test scores was created for four video chapters. Since the normality assumption was violated, the non-parametric Mann-Whitney U test for comparison of demonstration and interactive learning group's pre-test scores was applied. No significant difference was found (U=303.5, p > 0.05, 2-tailed).

Considering the post-test scores, the Mann-Whitney U test was applied to the composite variable, containing post-test scores for all video chapters. Also, no significant difference was found when comparing the demonstration and interactive learning group (U=280.5, p > 0.05, 2-tailed).

The descriptive statistics on learners' score for pre-test and post-test considering each video chapter is shown in Table 2. The data show that video learning was successful for both groups and that the interactive group scored slightly better compared to the demonstration group.

In addition, the composite variable was created considering learners' satisfaction. The results of the Mann-Whitney U test revealed that students in the learning group with interactive video reported a statistically significantly higher level of instructiveness compared to the demonstration group (U=208.5, p= 0.018, sig≤.05, 2-tailed). Also, the effect size was intermediate (r = 0.324). Investigating each dimension separately, we found statistically significant differences for two video chapters: video 2 (U=228.0, p = 0.033, sig≤.05, 2-tailed) and video 3 (U=228.0, p = 0.026, sig≤.05, 2-tailed).

Table 2: Descriptive statistics on learners' pre- and post- test scores

Test and group	Statistic	Video 1	Video 2	Video 3	Video 4
Pre-test (n=24)	Median (%)	40 (IQR=65)	14 (IQR=22)	67 (IQR=67)	50 (IQR=100)
Demonstration	Average (%)	48	20	65	58
Pre-test (n=28)	Median (%)	40 (IQR=45)	14 (IQR=33)	42 (IQR=67)	75 (IQR=100)
Interactive	Average (%)	46	19	60	55
Post-test (n=24)	Median (%)	100 (IQR=20)	100 (IQR=29)	100 (IQR=17)	100 (IQR=12)
Demonstration	Average (%)	91	79	90	81
Post-test (n=28)	Median (%)	100 (IQR=0)	100 (IQR=18)	100 (IQR=0)	100 (IQR=0)
Interactive	Average (%)	96	84	98	86

Table 3 shows descriptive statistics on the level of learners' satisfaction (answers were given on a 5-point Likert scale ranging from poor = 1 to excellent = 5). The data show that the interactive learning group perceived video learning more instructive compared to the demonstration group. Also, a higher level of instructiveness has been revealed in students with either low prior knowledge (video 2) or medium prior knowledge (video 3).

However, when the learning content was well known to students, they perceived it as less instructive (compare Table 4, pre-test 4 and Table 3, video 4).

Table 3: Descriptive statistics on learners' satisfaction

Group	Statistic	Video 1	Video 2	Video 3	Video 4
Demonstration	Median	4.0	4.0	4.0	4.0
n = 24	Average	4.0	3.8	4.2	3.5
Interactive	Median	5.0	5.0	5.0	4.0
n = 28	Average	4.5	4.5	4.6	4.0

Table 4 shows pre-test and post-test results for both groups in all 4 video chapters, i.e. the total number of points achieved by students in each group (%). Each of the 4 tests had its own scoring scale due to the complexity of the tasks. Table 4 shows the percentage of students achieving each of the score categories in each group (interactive / demonstration).

The overall data show that learning with both types of videos designed in accordance with the principles of instructional design was successful.

Discussion

This study aimed primarily to investigate the impact of interactive video tutorials on the effectiveness of procedural learning and student satisfaction, and to analyse attention cues made by instructional designers in both demonstration and interactive videos, for software training with undergraduate informatics students. The quantitative analysis did not find statistical significance in students' procedural learning outcomes when demonstration and interactive groups were compared, but the analysis demonstrated a higher satisfaction with interactive videos, which were perceived as more instructive compared to the demonstration videos.

Table 4: Pre-test and post-test results for demonstration vs. interactive videos (all chapters): Total number of points achieved by students in each group (%)

Test points	Pre-test 1 (max. 5 points)		Post-test 1 (max. 5 points)	
	Demonstration % n = 24	Interactive % n = 28	Demonstration % n = 24	Interactive % n = 28
0	4.17%	0%	0%	0%
1	33.33%	39.29%	0%	0%
2	33.33%	32.14%	8.33%	0%
3	0%	3.57%	0%	3.57%
4-5	29.16%	25%	91.67%	96.43%
Test points	Pre-test 2 (max. 7 points)		Post-test 2 (max. 7 points)	
	Demonstration % n = 24	Interactive % n = 28	Demonstration % n = 24	Interactive % n = 28
0	25%	32.14%	0%	3.57%
1	37.50%	39.29%	0%	0%
2-3	33.33%	21.43%	20.83%	10.71%
4-5	4.17%	3.57%	16.67%	10.71%
6-7	0%	3.57%	62.50%	75%
Test points	Pre-test 3 (max. 6 points)		Post-test 3 (max. 6 points)	
	Demonstration % n = 24	Interactive % n = 28	Demonstration % n = 24	Interactive % n = 28
0	0%	0%	0%	0%
1	0%	0%	0%	0%
2	37.5%	50%	4.17%	0%
3-4	29.16%	17.86%	12.5%	3.57%
5-6	33.33%	32.14%	83.33%	96.43%
Test points	Pre-test 4 (max. 2 points)		Post-test 4 (max. 2 points)	
	Demonstration % n = 24	Interactive % n = 28	Demonstration % n = 24	Interactive % n = 28
0	29.16%	39.29%	12.5%	14.29%
1	25%	10.71%	12.5%	0%
2	45.83%	50%	75%	85.71%

Our findings on satisfaction are in line with the results found by Kwame et al. 2015) and Zhang et al. (2006). Also, similar to Kriz & Hegarty's (2007) conclusion regarding the influence of interactivity on learning, we also believe that more emphasis should be placed on how prior knowledge is applied to interpreting tasks in video tutorials, since our study revealed statistically significant higher level of instructiveness in students with either low prior knowledge or medium prior knowledge. Unfortunately, we cannot compare our results to those of the recent study by Keller et al. (2019), as they compared outcomes from interactive video with outcomes from PDF manuals. We are not aware of any other study that analyses the influence of interactive video tutorials on either student satisfaction or procedural learning performance in comparison with demonstration videos (or text manuals) for software training.

Our findings may be important for demonstration video as well as interactive video. Our results suggest that instructive video design which combines multimedia learning principles and demonstration-based training yields positive procedural learning results for students, using either demonstration or interactive videos. We attribute this to the retention-supportive role of attention cueing, which is in line with results from some previous studies revealing that cueing guides the learner's attention and fosters learning (Boucheix & Lowe, 2010; Hassanabadi, Robatjazi & Savoji, 2011; Mayer & Fiorella, 2014; van Gog, 2014).

A demonstration video can also be used in an interactive way, (e.g. viewing of a demonstration video can be interspersed with structured discussion facilitated by the tutor). Cueing has been identified as especially important in learners with low to medium prior-knowledge (Richter, Scheiter & Eitel, 2016) and, again, our results for both demonstration and interactive videos support previous literature.

Significance of the study and guidelines for educators

Application of the multimedia learning principles provided by Mayer (2017, p. 407-414) and guidelines provided by van der Meij and van der Meij (2013, p. 207) in this study provided the framework for incorporating video learning into instructional design. In this section, the main guidelines for educators are emphasised, as a contribution of this study to the implementation of interactive video tutorials for software training.

The video tutorials should be short, around three minutes in duration and preferably divided into chapters to allow easy access and a meaningful segmentation of tasks. Since they aim to provide procedural rather than conceptual information, they should be designed as a sequence of actions recorded with the corresponding voice instructions. All tasks should be anchored in the task domain of students and tasks should be kept clear and simple. Instead of using demonstration videos (where students are required to watch the recorded tutorials), we recommended interactive videos where students must either correctly click on the required part of the window, or type in the required content to continue with the tutorial.

At the beginning of the video, students need to preview the task and get instructions that the video would stop at each important new step until they perform the required action. It is advisable to strengthen the demonstration with practice. Also, students can be given a choice to turn textual and spoken explanations on or off during the video, to ensure that subtitles or audio are not redundant.

In addition, functional interactivity should be enabled (e.g. to rewind the video, pause it, etc.) so that students could adapt their interaction with videos according to the subjective (perceived) difficulty of the chapter, their own abilities or learning strategies. Finally, some types of signalling (colour, italicised or bolded letters, pointing arrows, circling, underlining, flashing or spotlighting) should be used to boost processing efficiency and help a learner to achieve the better integration of new content.

Conclusion

The aim of this study was to address the research gap identified by Strecker et al. (2018) concerning the effects of interactive videos in educational contexts, as well as the influence of interactive videos on learner performance and satisfaction compared to demonstration videos. We attempted to fill this gap by investigating two comparable media formats, i.e. interactive video tutorials and demonstration video tutorials in software training. This study has focused on assessing the impact of interactive video tutorials on learning effectiveness and student satisfaction while acquiring application-orientated knowledge. The analysis of signalling made by instructional designers in both demonstration and interactive videos was carried out to develop high-quality instructional video materials.

The paper supports earlier findings in the literature that attention cues foster learning, especially in students with low to medium prior-knowledge (Richter, Scheiter & Eitel, 2016), and shows that cues could be used in both demonstration and interactive video tutorials. Both types of video tutorials had a positive effect on the learning process, and both have achieved very good learning outcomes.

Another contribution of the study is the enrichment of understanding of the possible impact of interaction in videos on students' satisfaction and learning. Students who used interactive videos have achieved slightly better learning outcomes and evaluated these videos as more instructive, reaffirming the earlier findings about the positive effect of interactivity in educational video tutorials (Kwame et al. 2015; Zhang, 2006).

Also, the study provided important insights into why interactive videos are more instructive in software training for students with low to medium prior-knowledge, compared with demonstration videos. The study has implications for instructors who use demonstration videos as well as interactive videos in their classroom or online teaching.

It is important to emphasise that there were certain limitations. The sample size did not allow broader generalisations and it was not representative of the larger population of undergraduate informatics students. The focus of this study was solely on the effectiveness of procedural learning and student satisfaction.

In order to gain a deeper insight into students' appreciation of the videos and their suggestions for other kinds of improvements in teaching and learning for informatics students, an important avenue for further research could be qualitative studies. Also, a study should be conducted to analyse the effect of both demonstration and interactive videos on the acquisition of declarative knowledge and the effects of these videos on near and far knowledge transfer.

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Please cite as: Mikelić Preradović, N., Lauc, T. & Panev, I. (2020). Investigating interactivity in instructional video tutorials for an undergraduate informatics course. *Issues in Educational Research*, 30(1), 203-223. http://www.iier.org.au/iier30/mikelic-preradovic.pdf