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A comparison of paper-based and video tutorials for software learning

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ABSTRACT

Instruction on software usage has long been dominated by the paper-based tutorial. This dominance is now being challenged with the rise of facilities for producing and publishing recorded demonstrations (video). Typically, each instructional medium has its own qualities. The present study aimed to optimize the design of a video tutorial for software training by attending to both its strengths and its weaknesses vis-à-vis a paper-based tutorial. Based on a distinction between two functionally different components in software tutorials, four tutorial configurations were compared: Paper-based, Mixed A (paper-based preview and video procedure), Mixed B (video preview and paper-based procedure), and Video. The 111 fifth and sixth grade participants (mean age 11.8) received instructions about Word's formatting options. The findings indicated significant and substantial improvements from pre-test to training in all conditions. In addition, participants in the Mixed A, Mixed B, and Video conditions outperformed those in the Paper-based condition. Significant and substantial learning gains were found from pre-test to post-test. Both the Mixed B and Video conditions outperformed the Paper-based condition. The success of the Mixed A, Mixed B, and Video tutorials is ascribed to the use of design guidelines for software training that direct the designer to optimize video's strong qualities and moderate or reduce its relative weaknesses.

1. Introduction

Until recently, paper-based tutorials were the primary means of supporting procedural knowledge development by software users (van der Meij, Karreman, & Steehouder, 2009). Video is increasingly challenging this dominance, as technological barriers to its production and distribution have been removed. Websites from companies such as Adobe, Apple, HP, Microsoft, Samsung, Sony, Dell and the like now feature dozens upon dozens of 'How to' videos for their clients. The arrival of YouTube on the Internet in 2005 also marked the debut of the user as designer. As a result, there are now several specialized websites with thousands of user-made 'How to' videos (e.g., eHow, Howcast, Videojug, and Wonderhowto).

With video fast becoming the primary medium for instructing users about procedures, questions arise as to its design and effectiveness. Is a video tutorial a good alternative for the paper-based tutorial? In this paper we investigate this question for procedural knowledge development for software tasks. The most suitable video instruction for this purpose is considered to be the screencast or recorded demonstration in which a screen recording is coupled with narration (Lloyd & Robertson, 2012; Mestre, 2012; Plaisant & Shneiderman, 2005). In this paper we will use the generic term video to refer to such demonstrations.

We begin by reviewing the theoretical and empirical research on paper-based and video tutorials. This is followed by an empirical study comparing paper-based, video, and mixed tutorials on formatting tasks with Microsoft Word.

1.1. Theoretical arguments in favor of paper-based tutorials

Important *arguments favoring a paper-based tutorial* over a video tutorial for procedural knowledge development are its structure, accessibility, pace control, and active processing. The structure of a paper-based tutorial is such that it easily provides the user with an

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overview of the contents of the training. A table of contents shows how the instructional material is organized. In addition, the user can quickly skim the pages to get a first impression of the nature of the task instructions. Moreover, the table of contents makes it easy for the user to find information on a specific task or step. This facility is especially important when the user wants to recap a procedure or step, and when task execution breaks down. A paper-based tutorial does not dictate the speed of processing. The pace is set completely by the user, who can decide to move quickly with task instructions that are easily understood, and to move slowly with complex instructions. Another advantage of paper-based tutorials is that they invite active processing by the user. They are attuned to the user's tendency to act, and they call upon self-explanatory processes. Good tutorials are aligned with people's inclination to be active and to work toward meaningful goals when becoming familiar with software (Carroll, 1990, 1998). Such tutorials quickly get the user to where his interests lie, namely to instructions for task completion. The user must interpret these instructions for what they say about what needs to be done and about what happens in the human–computer interaction. According to Bovair and Kieras (1991), procedure comprehension in a paper-based tutorial engages the user in three vital processes, namely acquisition monitoring, immediate transfer, and procedure construction. In these processes the user actively monitors task progress, oversees the steps that still need to be taken, connects a new procedural step to one already acquired, and integrates the information from the instructions with what is already known. More generally, one could say that a paper-based tutorial stimulates active learning because it requires users to interpret instructions, and to produce self-explanations during task execution (see Catrambone & Yuasa, 2006).

1.2. Theoretical arguments in favor of video tutorials

Important *arguments favoring a video tutorial* over a paper-based tutorial lie in the affordances that video offers for multimedia representations, congruity, and modeling. Presenting instructions on video has the advantage that information can be presented in multiple modalities. According to dual coding theory (Clark & Paivio, 1991; Paivio, 1986), auditory and visual information can strengthen each other, and their combined use can partially overcome the processing demands with a single modality. Another advantage of a video tutorial is that it can display a task sequence just as the user would see it on his computer screen. There is congruence between the screen capture animation and real-life task execution (Tversky, Bauer-Morrison, & Bétrancourt, 2002). As the video dynamically visualizes screen changes it assists the user in perceiving temporal changes, or movements in a software system. A further advantage of video is that it provides the user with an easy-to-follow model. When learning about software from video instructions the user can easily (learn to) mimic the observed actions.

1.3. Empirical studies comparing a paper-based and video tutorial

Empirical research has rarely studied the effectiveness of a paper-based versus a video tutorial for procedural knowledge development. In their meta-analysis on static versus dynamic representations, Höffler and Leutner (2007) reported having found only two such studies for procedural knowledge development. This research (i.e., Michas & Berry, 2000; Spangenberg, 1973) did not contrast a paper-based and a video tutorial, however. Our literature search revealed the presence of three recent empirical studies. In addition, we found two early studies on software training that we describe below along with the newer ones.

Payne, Chesworth, and Hill (1992) conducted an experiment in which participants received instructions on how to use MacDraw for drawing, moving and deleting figures on the Macintosh. Four conditions were compared: no instructions (control), paper, video, and paper with video. The paper-based tutorial consisted of a set of seven independent cards. These "Exploration Cards" (see Carroll, 1990) presented the user with a generic goal (e.g., "Drawing objects") and a small set of similarly generic task descriptions (e.g. "Point and click to select the required figure from the column on the left of the screen"). There were no screenshots on these cards. The video was 2.5 min long. It was an animated demonstration without commentary that showcased the manipulation of discrete figures. There were 8 participants in each condition. The only difference found between conditions concerned task completion time. Participants in the control condition were significantly slower than in the other conditions, which did not differ from each other.

Palmiter and Elkerton (1993) conducted an empirical study in which participants received instructions on how to use HyperCard. Three conditions were compared: paper without screenshots, video without narration, and video with narration. Training involved a series of 18 programming tasks. There were 16 participants in each condition. The main findings were as follows. Participants who viewed a video tutorial completed training significantly faster than those reading instructions on paper. The video tutorials also yielded significantly more accurate training performance. On a retention test taken one week later, the performance scores had decreased for video and increased for paper, resulting in an absence of a significant difference for condition. Task completion time was significantly faster for the paper-based tutorial, however. Palmiter et al. ascribed these outcomes to mimicry. That is, the video demonstrations may have induced superficial processing, with users more easily falling into the trap of an illusion of understanding.

Lloyd and Robertson (2012) conducted two consecutive studies on tutorials that taught students how to enter data and perform a *t*-test in SPSS. A paper-based tutorial with screenshots and a 12 min video tutorial with narration were developed for these tasks. The first study, with 31 participants, found that the video tutorial yielded significantly better results on a post-test than the paper version, with more tasks completed in a shorter time. In the second study, the 22 participants were given more time to complete training. In addition, they were allowed to review the tutorial during testing. The findings showed that the video group still completed significantly more tasks, but no longer had a time advantage.

Mestre (2012) conducted an experiment in which participants received instructions on how to find articles in ERIC, or Online Research Resources. A static webpage tutorial (the near equivalent of a paper-based version) and a video tutorial were created for each database. Video length was either 2 or 3 min. The 21 participants in the study were trained in both tasks, receiving a static webpage tutorial with screenshots in one and a video tutorial in the other. After training, a large majority (76%) of the students expressed a clear preference for the static webpage tutorial. In addition, the static webpage tutorials yielded substantially higher performance success on a post-test. Participants in the video condition had difficulties finding the right steps even though the video had chapter markers. They preferred to use the static webpage to find the information needed quickly. They did not want to take the time to watch the whole video. In addition, several participants suggested adding small video clips to the static webpage to demonstrate a feature.

In Alexander's (2013) empirical study, participants received instructions on how to use Word for Mail Merge (MM), and for automatically creating a table of contents (TOC). A paper-based tutorial with screenshots and a video tutorial with narration was created for each task. For MM, the paper-based tutorial consisted of 24 pages, and the video took 13.30 min. For TOC, the paper-based tutorial consisted of 9 pages, and the video was 3 min long. The 28 participants in the study received the paper-based tutorial for one task, and the video tutorial for the other. The study was designed as a usability test. That is, participants were told to refer to the tutorial when needed for task completion rather than using the tutorial for training prior to being tested for learning. The outcomes revealed very few differences between paper-based and video tutorials on measures of success and satisfaction with the medium. Task completion rates for both tasks and tutorial types were well above 90%, and the standard deviations also indicated only small differences between participants. An interesting difference was reported in how the participants processed the tutorials. The videos generally were watched in full before task execution. In contrast, when working with a paper-based tutorial participants would try to complete the task first, turning to the tutorial only when they needed specific instructions. The results further showed that participants in the video condition had significantly more trouble accessing information. Comments made were: "Finding the exact position of reference in the video was time-consuming and frustrating", "If I couldn't remember the step, I had to re-watch the entire video, which took longer and slowed me down", and "It was a hassle to find the information I needed" (p. 249).

In short, empirical research comparing paper-based and video tutorials for software training is scant and outcomes have been mixed. The studies by Payne et al. (1992) and Alexander (2013) showed no specific benefits of either medium. Mestre's (2012) research favored the static webpage tutorial, whereas the study by Lloyd and Robertson (2012) yielded better results for video. Finally, the research by Palmiter and Elkerton (1993) showed that both paper-based and video tutorials each yielded specific benefits. One reason why video tutorials sometimes did not yield better results than paper-based tutorials could be that the relative weaknesses of video were not sufficiently addressed. For instance, several studies reported on the limited accessibility of information in the video tutorial. Similarly, the mimicking effect reported by Palmiter and Elkerton (1993) refers to the risk that video does not sufficiently engages the user in active processing. The use of a silent video by Payne et al. (1992) illustrates another point, namely an underuse of the video strength of multimodality.

1.4. Experimental design and research questions

The construction of the video tutorial in this study was based on the set of design guidelines for software training recently advanced by van der Meij and van der Meij (2013). These guidelines aim to optimize the strengths and minimize the weaknesses of video compared to paper-based tutorials. The following section briefly discusses how the video tutorial aimed to overcome the obstacles of limited overview, limited accessibility to specific (sub-)tasks, risk of passive processing of information, and limited pace control.

The issue of *limited overview* was addressed by providing the user with task previews. Each task preview appears immediately before the pertinent procedure that gives the user step-by-step instructions for task execution. The preview provides an overview and does not require the user to self-execute the procedure or see it demonstrated. Just as advance organizers have been found effective for conceptual knowledge development (e.g., Ambard & Ambard, 2012; Ausubel, 1968; Gurlitt, Dummel, Schuster, & Nückles, 2012; Hartley & Davies, 1976), it is assumed that previews are important for procedural knowledge development in software training (compare Kriz, 2011).

In addition, the present study employed the previews to enhance perceptions of task utility and appraisals of the chances for success. That is, the previews display before and after states to convince the user of the value of attempting task completion, and they give the impression that task execution is within the user's reach. In this way the previews address the two key components from expectancy-value theory, namely task relevance and self-efficacy (Eccles & Wigfield, 2002).

The issue of *limited accessibility* was addressed by providing a table of contents as the main port of entry for both the paper-based and video instructions. In addition, all content is segmented into meaningful and manageable units of information (compare Mayer, 2005). Moreover, the length of the videos is restricted to a maximum of two minutes to make it easier for the user to locate (sub-)tasks within a video.

The risk of *passive processing* was addressed by the use of highlighting, and the inclusion of exercises for practice. In both the previews and the procedures, common highlighting techniques are used to draw the user's attention to vital screen objects or areas. After a procedure, the user is prompted to engage in practice on that task to consolidate and enhance learning. The value of coupling a video tutorial with practice was demonstrated in an experiment by Ertelt (2007; see also Rieber, 1991). Her study found that the opportunity for practice after video instructions significantly improved user performance after training compared to a non-practice control condition. In Ertelt's study, access to the video instructions was blocked during practice for reasons of experimental control. In the present study the participants can access the tutorial during practice, just as they would for other job aids.

The issue of *limited pace control* is arguably the most difficult to address in the construction of a video tutorial. Apart from pilot testing with the target audience, and the inclusion of a common set of user controls (e.g., stop, play, pause, replay), the leading design guideline is the apprehension principle from Tversky et al. (2002), which states that animations should be readily and accurately perceived and comprehended.

There were four experimental conditions: (1) Paper-based tutorial, (2) Mixed tutorial A with paper-based previews and video procedures, and (3) Mixed tutorial B with video previews and paper-based procedures, and (4) Video tutorial. This set-up affords both an overall analysis of medium and an investigation of its role in previews and procedures, a distinction that stems from the design guidelines.

Two research questions are addressed:

(1) *What are participants' absolute and relative levels of success in practice during training with software tutorials that are presented entirely on paper, entirely as video, as paper-based previews and video procedures, or as video previews and paper-based procedures?*
(2) *What are participants' absolute and relative levels of success in completing a post-test after learning with software tutorials that are presented entirely on paper, entirely as video, as paper-based previews and video procedures, or as video previews and paper-based procedures?*

It is expected that the video tutorial condition will yield better results than the paper-based tutorial condition for both practice during training and success in completing a post-test. It is conceivable that the presence of at least one video demonstration (preview or procedure)

will provide the user with sufficient congruent information on task execution. However, given the scant research on (design variations in) paper-based versus video tutorials no specific predictions for the mixed tutorials are advanced.

Prior to training, the participants' self-appraisals for task relevance and self-efficacy were measured to assess the validity of the assumption that the previews should address these factors. In addition, these measures served to gauge the influence of this possible confounding variable. There is a considerable body of research on the effects of motivation on learning behavior and outcomes (e.g., Bandura, 1997; Pintrich & Schunk, 2002). Perhaps more than elsewhere, this influence may come to the fore in the self-study context of learning from a tutorial. In other words, initial motivation was also measured to check on the random distribution of this factor.

2. Method

2.1. Participants

The participants consisted of 111 fifth and sixth graders (mean age 11.8 years; range 10.6–13.5). The 56 males and 55 females were from nine classrooms of five elementary schools. Students from a classroom were split into two groups that were randomly assigned to an experimental condition, while making sure that all four conditions were included. A check on their distribution revealed no differences between conditions for age or gender.

2.2. Instructional materials

The tutorials are identical in several respects. They aim to support the development of the participants' skills in using Word. More specifically, they address formatting tasks that are important for school reports. Earlier studies have indicated that students from this age group generally do not yet know the best method, if any, for accomplishing these tasks (references withheld for blinding). The tasks are organized into three 'chapters' (see Fig. 4). The first deals with adjusting the left and right margin for a whole document. The second concentrates on formatting paragraphs, citations, and lists. The third chapter deals with automatically generating a table of contents.

A distinction is made between previews and procedures. *Previews* explain a key concept (e.g., margin, paragraph, list), display a poorly done and an improved format, and introduce the objects to be manipulated in Word. Previews invariably precede the corresponding procedure(s). *Procedures* describe, and sometimes explain, all of the user actions and software reactions in accomplishing a formatting task.

Students practiced the formatting tasks during training using specifically designed *practice files*. These files made task completion efforts comparable across conditions. During completion of training tasks, the participants had access to the tutorials.

For pre-training, a scaled-down version of the website with videos was created for students to explore website navigation, to acquaint them with the difference between a preview and a procedure, and to practice switching between video and/or paper and hands-on experience.

2.2.1. Paper-based tutorial

The design of the procedures for the paper-based tutorial follows the guidelines from the Streamlined Step (Farkas, 1999) and the Four Components Model (van der Meij, Blijleven, & Jansen, 2003; van der Meij & Gellevij, 2004). Fig. 1 displays an example of a *preview* from the paper-based tutorial. The header signals that this is a page that students simply need to read. The title and text beneath it explain the concept. In this case the notion of a paragraph is explained and the student is informed about how a paragraph should be formatted. Next, a picture illustrates the before and after state for formatting paragraphs. The corresponding description of problem and solution emphasizes the relevance of the formatting task for the student. Finally, the student is directed to the screen object(s) involved in the procedure. A preview is always presented on a single page in the paper-based tutorial.

Fig. 2 displays an example of a *procedure* from the paper-based tutorial. Procedures describe and illustrate the human–computer interaction in a two-column set-up. The numbered action steps on the left tell the users what to do. These instructions follow the standard action-on-object sequence (Farkas, 1999). Action verbs are presented in bold, and input objects are presented verbally and visually. The software reaction is described in the boxed text below the action, or the user is directed to the juxtaposed screenshot. In addition to identifying and locating screen objects, these screenshots should also help the user build a mental model of the unfolding (visual) scenario (Gellevij & van der Meij, 2004; Gellevij, van der Meij, de Jong, & Pieters, 2002; van der Meij, 2000; van der Meij & Gellevij, 1998). After reading about a procedure, the user is instructed to complete that task for a practice file. The average page length of a procedure is 1.7 pages (range 1–2 pages).

2.2.2. Video tutorial

The video tutorial is based on the Eight Design Guidelines for Instructional Videos (van der Meij & van der Meij, 2013). Fig. 3 presents an overview of these guidelines. We characterized these guidelines as design patterns (Carroll & Farooq, 2007), aspiring to make them sufficiently concrete for practitioners to follow in their design of video instructions for software learning, while also grounding them on pertinent, general design principles.

The videos are presented on a website where the screen is divided into two areas (see Fig. 4). The left-hand area with the table of contents is permanently visible to facilitate access. Just as in the paper-based tutorial, chapter titles refer to previews. On the website these titles are displayed on a dark blue background with an icon at the end to signal their status as for viewing only. Paragraph titles refer to procedures. They are presented on a lighter blue background and end with an icon that signals viewing followed by doing.

When the user clicks on a title, its background color changes to orange and the corresponding video appears on the right-hand side, along with a transparent control toolbar on the bottom (see Fig. 4). The user can set the video in motion by pressing the start icon. The user can also pause and resume, return to the starting point, and increase or decrease the sound level. A ruler shows how far the video track has progressed.

The demonstration in the video recording is accompanied by a narrative, spoken by a female voice. The narration conveys the same information as the written instructions in the paper-based tutorial, except for slight changes made to better mimic natural speech.

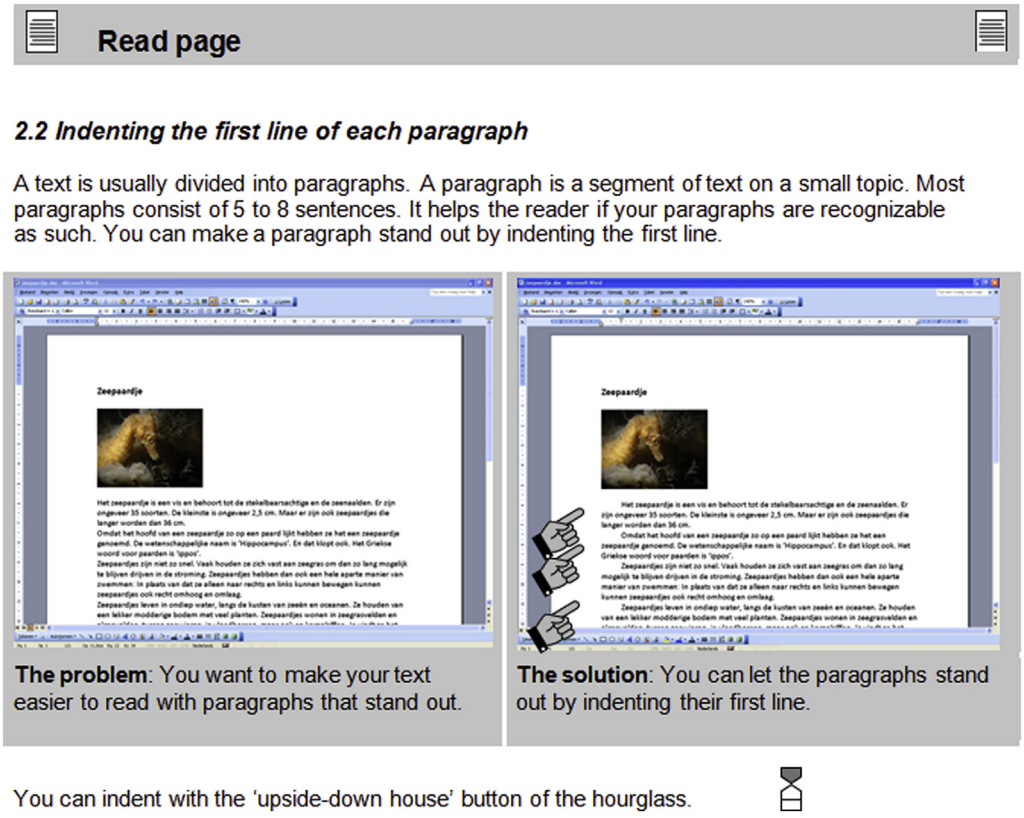

Fig. 1. A preview from the paper-based tutorial.

A *preview* in the video format consists of the same elements as in the paper-based tutorial. That is, it defines a concept, and displays the starting and ending screen of a task. Furthermore, the objects involved are highlighted by a big red circle (see Fig. 5). The average length of the previews is 1.15 min (range 1.00–1.33).

A *procedure* in the video format demonstrates an unfolding scenario of task completion. The actions and objects involved in these videos are the same as in the paper-based tutorial. User actions on input devices are described in the narrative and their result is visible on the interface. The narrative directs the user to these effects with standard phrases such as "You now see … ". Occasionally, the video zooms in on screen sections, and just as on paper, screen objects or areas are highlighted (see Fig. 5). A procedure ends by inviting the user to open a practice file and engage in hands-on practice. The average length of the procedural videos is 1.13 min (range 0.47–1.42).

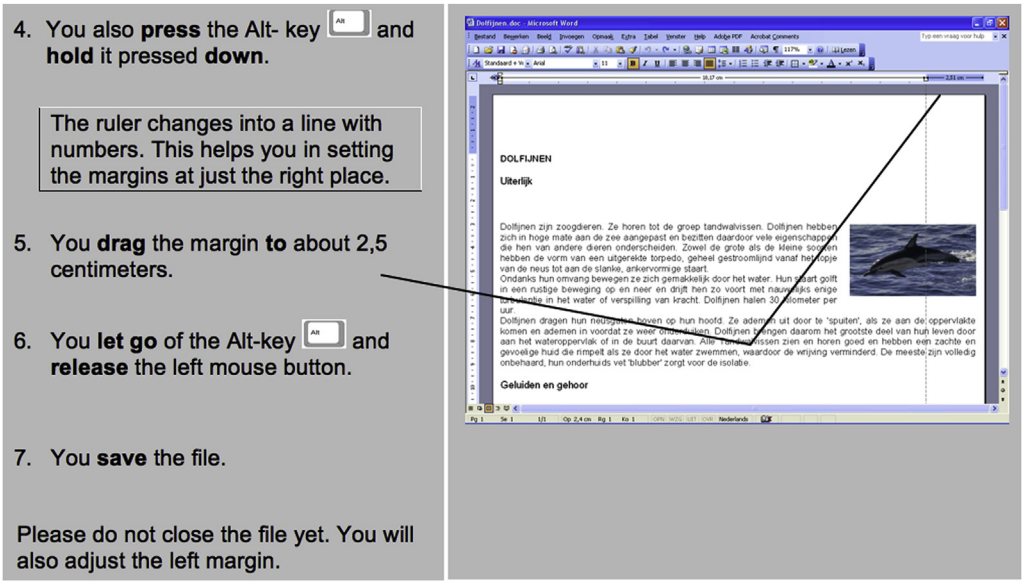

Fig. 2. A procedure from the paper-based tutorial.

 # 1: Provide easy access
1.1 Craft titles carefully, avoiding jargon
 # 2: Use animation with narration
2.1 Be faithful to the actual interface in the animation
2.2 Use a spoken human voice for the narration
2.3 Use a conversational style
2.4 Action and voice must be in synch
 # 3: Enable functional interactivity
3.1 Pace the video carefully
3.2. Enable user control
 # 4: Preview the task
4.1 Sell the goal
4.2 Introduce new content by showing its use in context
 # 5: Concentrate on giving procedural information
5.1 Include deliberate pauses to stimulate reflection
 # 6: Make tasks clear and simple
6.1 Follow the user's mental plan in describing an action sequence
6.2 Emphasize the interconnection of user actions and system reactions
6.3 Use signaling techniques to guide attention
 # 7: Keep videos short
 # 8: Strengthen demonstration with practice

Fig. 3. Guidelines for the creation of video tutorials for software learning.

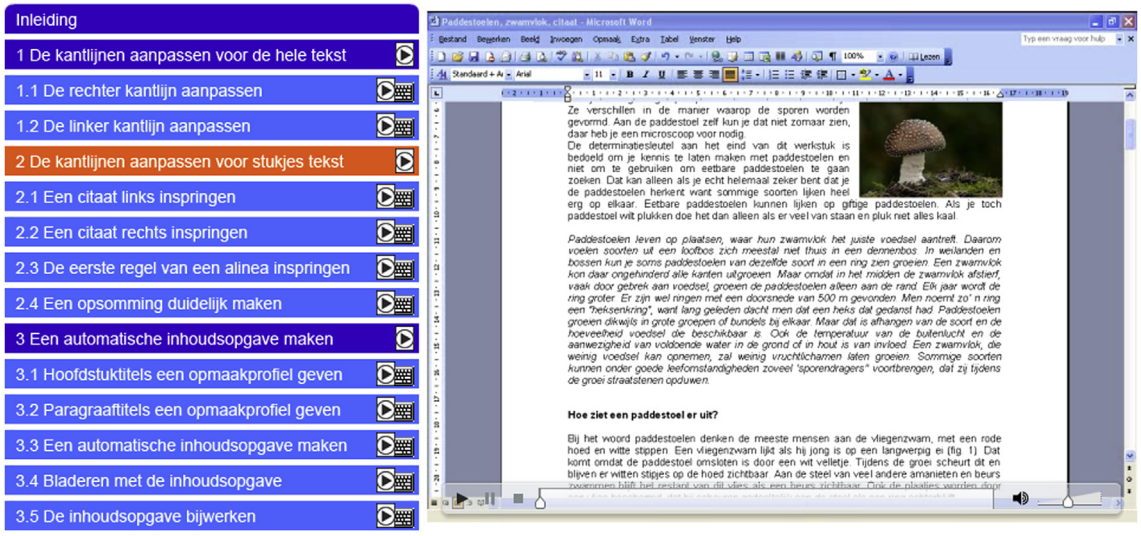

Fig. 4. Screenshot of the video website.

Fig. 5. A zoomed image with the key object highlighted.

2.2.3. Mixed tutorials

The two mixed tutorials were produced for the conditions in which students received instructions partially from paper and partially from video. In Mixed tutorial A, participants received the preview sections from the paper-based tutorial, along with directions to consult the corresponding procedures sections of the video tutorial. In Mixed tutorial B, participants saw the video previews from the video tutorial, along with directions to consult the corresponding procedures sections of the paper-based tutorial..

2.3. Instruments

2.3.1. Pre-test and post-test

A *Pre-test* measured the participants' task performance before training. It asked the participant to demonstrate initial software skill on the computer. During this test the participant was asked to modify the format of test files for the same tasks that would be trained. A score of 0 points was awarded for each task the user could not solve correctly. A correct solution yielded a score of 1. The maximum Pre-test score was 8, and scores were converted to a percentage of possible points.

A *Post-test* measured the participants' task performance after training. It asked the participant to complete the same formatting tasks as in training, using test files that differed only in appearance from those used in pre-testing. The test has been used multiple times in previous studies on software training (van der Meij, 2008, 2014). It is considered to have construct validity in that it assesses the participants' procedural knowledge development with hands-on tasks without access to instructional support. Content validity comes from the inclusion of test items that are superficially different, but fundamentally identical, with the trained and pre-tested tasks. Scoring is identical with the pre-test.

2.3.2. Initial Experience and Motivation Questionnaire (IEMQ)

An Initial Experience and Motivation Questionnaire (IEMQ) measured the participants' initial motivation. The IEMQ was used to check on the random distribution of participants across conditions for the potential confounding variables of motivation and experience. For each formatting task, the participant first saw a Before-After screenshot plus explanation, and was then asked three questions: (a) "Do you ever have to do this task?" (Experience), (b) "How often do you need to complete this task?" (Task relevance), and (c) "How well do you think you can complete this task?" (Self-efficacy). The student answered these questions by circling a number on a 7-point Likert scale where the end points were given as *never – always*, or *very poorly – very well*. Good reliability scores (Cronbach alpha) were found for Experience (0.77), Task relevance (0.87) and Self-efficacy (0.83). The IEMQ is an adapted version of the FAM-questionnaire from Rheinberg, Vollmeyer, and Burns (2001). The IEMQ has been used multiple times in previous studies on software training. Significant positive relationships have been found between measures of initial Task relevance and Self-efficacy and motivational measures during and after training (van der Meij, 2014).

2.3.3. Training tasks

Students engaged in hands-on practice during training. The formatting problems they had to solve in training were presented through practice files. During these attempts the students had access to the tutorial. Training task performance was measured in the same way as for the Pre-test. For two participants no scores could be computed because their files were not saved.

2.4. Procedure

The experiment was conducted in two sessions, one classroom at a time. In the first session students were told (5 min) that they would engage in training on Word to assist them in improving the formatting of their school reports. Next, they were instructed to complete the IEMQ and Pre-test (20 min). The training session followed a day later. Within a classroom all of the students in the same condition had the training session simultaneously. When these children were returned to their classroom, another group would be picked up for their training session. This session started with a 10-min procedural introduction. For the Paper tutorial condition with both previews and procedures on paper, the distinction between the preview and procedure was explained, as was the handling of training files. In the Mixed and Video tutorial conditions, website navigation was explained in a scaled-down website and here, too, attention was drawn to the distinction between preview and procedure and the handling of training files. The children in the Mixed and Video tutorial conditions all used headphones during the training session, which prevented talk. After the introduction was over, the students were told to work independently for 50 min and to call for assistance only when stuck. After training was completed there was a 10-min break followed by the Post-test, for which the students were given 20 min. Students were not allowed to consult the tutorial during this test.

2.5. Analysis

The data from the IEMQ were analyzed to check on the random distribution of participants across conditions. These analyses revealed no difference between conditions on their initial experience or motivational measures (see Table 1). The scores reveal that the participants' initial perceptions of task relevance were below the scale means, supporting the design decision to address this factor in the previews. For self-efficacy the scores were already above the scale means, suggesting that this factor did not need to be addressed in the previews. Both overall scores are virtually identical with the findings for initial motivation obtained in a recent study with participants from the same target group (reference withheld for blinding).

ANCOVAs were computed to examine procedural knowledge development during and after training, using the pre-test scores as a covariate. Prior to these tests, the distributions were checked for possible violations of homogeneity (Levene test). All tests are two-tailed with alpha set at 0.05. For significant main results, pairwise comparisons are computed using Tukey's LSD post-hoc test. Cohen's (1988) *d*-statistic is used to report effect size. These tend to be qualified as small for $d = 0.2$, medium for $d = 0.5$ and large for $d = 0.8$.

Table 1
Means[a] (and standard deviations) of task-relevance and self-efficacy per condition.

Condition	Experience	Task-relevance		Self efficacy	
	M (SD)	M	(SD)	M	(SD)
Paper tutorial ($n = 27$)	2.80 (1.20)	2.99	(1.53)	4.21	(1.59)
Mixed tutorial A (paper preview & video procedure) ($n = 29$)	2.77 (1.18)	2.97	(1.51)	4.78	(1.04)
Mixed tutorial B (video preview & paper procedure) ($n = 27$)	2.50 (1.26)	2.76	(1.74)	4.79	(1.53)
Video tutorial ($n = 28$)	2.74 (1.32)	2.81	(1.38)	4.21	(1.57)
Total ($n = 111$)	*2.70 (1.23)*	*2.88*	*(1.52)*	*4.50*	*(1.45)*

[a] Scale values range from 1 to 7; the scale midpoint is 3.5; a higher score indicates a higher appraisal.

3. Results

3.1. Success completing the training tasks

The participants were highly successful in completing the training tasks (see Table 2). The average success rate of 81.5% for these tasks for all participants together meant a significant and highly substantial increase over the average pretest score of 24.1%, $F(1, 107) = 562.18$, $p < 0.001$, $d = 2.52$.

An analysis of covariance on training tasks, with pre-test scores as covariate, yielded a significant effect for condition, $F(3,104) = 7.49$, $p < 0.001$. Unfortunately, a high variance in the Paper tutorial condition caused a violation of the assumption of homogeneity of variance (Levene test) for the comparisons on the training tasks across all four conditions. Therefore, we first compared the scores for the other three conditions (the Levene test signaled no violation here). There were no differences among these conditions, $F(2,79) < 1$. Next, we compared the Paper tutorial condition with Mixed tutorial A (paper preview & video procedure) because the Levene test revealed no violation of this assumption of homogeneity for this comparison. In this case a significant effect of condition was found, $F(1,51) = 7.60$, $p < 0.01$, favoring participants receiving Mixed tutorial A. On the basis of these analyses, it seems fair to conclude that participants who had (partially) received video instructions were more successful in completing the training tasks than those who used the paper-based tutorial.

3.2. Success completing the post-test

Participants in all conditions considerably increased their computer skills from pre-test to post-test (see Table 2). The average success rate of 68.9% on the post-test for all participants together meant a significant and highly substantial increase over the average pretest score of 24.1%, $F(1, 107) = 277.38$, $p < 0.001$, $d = 1.88$.

Participants scored lower on the post-test than on the training tasks. The average drop for all participants together was from 81.5% to 68.9%. This change was significant and substantial, $F(1, 107) = 30.13$, $p < 0.001$, $d = 0.48$. The absence of an interaction of this effect of time with condition (i.e., $F < 1$) indicated that the decline occurred in all conditions.

An analysis of covariance on successful completion of post-test tasks, with pre-test scores as covariate, yielded a significant effect for condition, $F(3,106) = 2.82$, $p = 0.043$. The Levene test revealed no violation of the assumption of homogeneity. Pairwise comparisons (LSD) indicated that there were significant differences between the Paper tutorial condition on the one hand, and two of the video conditions (i.e., Mixed tutorial B, video preview & paper procedure, $p = 0.013$, and Video tutorial, $p = 0.013$) on the other. The comparison with Mixed tutorial A (paper preview & video procedure) was not significant ($p = 0.106$). There were no differences among the three conditions with video elements.

4. Discussion

The results clearly favor the presentation of software instructions via video rather than on paper. The most pronounced difference between these media was found during training. While the participants who worked with the paper-based tutorial successfully completed 63% of the training tasks, participants who had viewed a video achieved a success rate of 87%. This is in line with results from the study by Palmiter and Elkerton (1993), who also found that video tutorial users were more accurate than users of paper-based instructions during training. The absolute level of the participants' task performance in the conditions with video elements is also noteworthy. The findings show that the instructions served their purpose well of enabling software usage for Word's formatting tasks.

Table 2
Means[a] (and standard deviations) of pre-test, training tasks and post-test scores.

Condition	Pre-test		Training tasks		Post-test	
	M	(SD)	M	(SD)	M	(SD)
Paper tutorial ($n = 26/27$)[b]	19.4%	(18.1)	65.4%	(29.2)	55.6%	(34.4)
Mixed tutorial A (paper preview & video procedure) ($n = 27/28$)[b]	25.9%	(23.3)	87.0%	(22.9)	69.2%	(22.9)
Mixed tutorial B (video preview & paper procedure) ($n = 28$)	21.4%	(12.2)	88.8%	(15.0)	73.7%	(22.9)
Video tutorial ($n = 28$)	29.5%	(23.1)	89.7%	(14.0)	76.8%	(23.7)
Total ($n = 109/111$)	*24.1 %*	*(19.9)*	*81.5 %*	*(25.3)*	*68.9 %*	*(27.2)*

[a] The original means are reported.
[b] The data for Training tasks were missing for one participant in this condition.

During the post-test the instructional support of access to the tutorial was withdrawn so that a learning effect could be measured. Participants using the video tutorial did significantly better than those with the paper-based tutorial on this test as well. Even though these scores did not match those during training, the mean success rate of 73% was still considerable and substantially above the starting level of 24%.

In the set-up of the tutorial a distinction was made between a preview and a procedure. Each of these instructional units had a specific functionality. The preview served mainly to develop a general, condensed schema for task completion, introduced key terms and acquainted the user with pertinent screen locations and objects. In addition to these cognitive functions, the preview was also intended to raise task-relevance perceptions and self-efficacy beliefs. The procedures that followed then led the user through the steps for task completion. They were designed to direct the user's attention to the intricate relationships between user actions and software reactions, signal vital objects or movements, and include short, deliberate pauses to stimulate reflection, among other features. The Mixed A, B, and Video conditions differed in presentation medium for these units, but this made (almost) no difference for the outcomes. The presence of video instruction as either preview or procedure was sufficient for producing a difference in training and learning outcomes compared to the Paper-based tutorial. The decision to present both a preview and procedural instructions was based on the design guidelines for the construction of instructional video for software training recently advanced by van der Meij and van der Meij (2013). The criticality of the presence of the preview was assumed in these guidelines, but not tested. This is an issue for further study.

Follow-up studies are also called for to address two constraints of the current experiment. One limitation concerns the absence of measures of transfer. Both the training tasks and the post-test assignments were highly similar to the tasks on which the users were instructed. Because the ultimate aim of the training is to give the user the capability to complete a range of formatting tasks, future studies should investigate whether the instructions yield any transfer to untrained but related formatting tasks and whether users receiving video instructions also do better on these tasks.

Another limitation concerns retention. The present study measured learning immediately after training. This leaves open the questions whether there is good retention after a short delay, and whether video is then still more effective than paper. The empirical study by Palmiter and Elkerton (1993) revealed that a leveling off may occur when the video tutorial does not sufficiently prompt the necessary self-explanatory processes of the user. A recent study with participants of the same target group using the Video tutorial indicated that retention scores were at almost the same level as the outcomes on an immediate post-test (van der Meij, 2014). This outcome contrasts with the finding from Palmiter and Elkerton. The favorable retention scores seen in that more recent study are perhaps the result of specific design measures to activate user processing, as mentioned in the guidelines. This, too, is an issue for further study.

Ploetzner and Lowe (2012) recently argued that one reason why research on instructional animations has yielded heterogeneous outcomes probably lies in the great diversity of animations. As a first step towards a principled examination of the main characteristics of animation, they analyzed the body of existing studies, from which they abstracted an overview with four structural dimensions, namely presentation, user control, scaffolding, and configuration. This framework is quite useful, particularly for controlled experimentation.

Our study followed a different approach. Rather than becoming more abstract, we have become more concrete as we were challenged to put into practice general design principles for the construction of a video tutorial on software learning. The outcomes from our study speak quite favorably for the design that eventually resulted. A next step would be to classify this study along the dimensions that Ploetzner and Lowe distinguish, and then to set up experimental studies that can elucidate their criticality.

References

Alexander, K. P. (2013). The usability of print and online video instructions. *Technical Communication Quarterly, 22*, 237–259. http://dx.doi.org/10.1080/10572252.2013.775628.

Ambard, P. D., & Ambard, L. K. (2012). Effects of narrative script advance organizer strategies used to introduce video in the foreign classroom. *Foreign Language Annals, 45*(2), 203–228. http://dx.doi.org/10.111/j.1944-9720.2012.01189.x.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart & Winston.

Bandura, A. (1997). *Self-efficacy. The exercise of control*. New York, NY: Freeman and Company.

Bovair, S., & Kieras, D. (1991). Toward a model of acquiring procedures from text. In R. Barr, M. L. Kamil, P. Mosenthal, & P. D. Pearson (Eds.), *Handbook of reading research* (pp. 206–229). New York, NY: Longman.

Carroll, J. M. (1990). *The Nurnberg Funnel. Designing minimalist instruction for practical computer skill*. Cambridge, MA: MIT Press.

Carroll, J. M. (1998). *Minimalism beyond the Nurnberg Funnel*. Cambridge, MA: MIT Press.

Carroll, J. M., & Farooq, U. (2007). Patterns as a paradigm for theory in community-based learning. *Computer-Supported Collaborative Learning, 2*, 41–59. http://dx.doi.org/10.1007/s11412-007-9008-2.

Catrambone, R., & Yuasa, M. (2006). Acquisition of procedures: the effects of example elaborations and active learning exercises. *Learning and Instruction, 16*, 139–153. http://dx.doi.org/10.1016/j.learninstruc.2006.02.002.

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review, 3*(3), 149–210.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Eccles, J. S., & Wigfield, A. (2002). Motivation beliefs, values, and goals. *Annual Review of Psychology, 53*, 109–132. http://dx.doi.org/10.1146/annurev.psych.53.100901.135153.

Ertelt, A. (2007). *On-screen videos as an effective learning tool. The effect of instructional design variants and practice on learning achievements, retention, transfer, and motivation*. Doctoral dissertation. Germany: Albert-Ludwigs Universität Freiburg.

Farkas, D. K. (1999). The logical and rhetorical construction of procedural discourse. *Technical Communication, 46*, 42–54.

Gellevij, M. R. M., & van der Meij, H. (2004). Empirical proof for presenting screen captures in software documentation. *Technical Communication, 42*(2), 77–91.

Gellevij, M. R. M., van der Meij, H., de Jong, T., & Pieters, J. M. (2002). Multimodal versus Unimodal instructions in a complex learning context. *Journal of Experimental Education, 70*(3), 215–239.

Gurlitt, J., Dummel, S., Schuster, S., & Nückles, M. (2012). Differently structured advance organizers lead to different initial schemata and learning outcomes. *Instructional Science, 40*, 351–369. http://dx.doi.org/10.1007/s11251-011-9180-7.

Hartley, J., & Davies, I. K. (1976). Preinstructional strategies: the role of pretests, behavioral objectives, overviews and advance organizers. *Review of Educational Research, 46*, 239–265. http://dx.doi.org/10.2307/1170040.

Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: a meta-analysis. *Learning and Instruction, 17*, 722–738. http://dx.doi.org/10.1016/j.learninstruc.2007.09.013.

Kriz, W. C. (2011). A systemic-constructivist approach to the facilitation and debriefing of simulations and games. *Simulation & Gaming, 41*(5), 663–680.

Lloyd, S. A., & Robertson, C. L. (2012). Screencast tutorials enhance student learning of statistics. *Teaching of Psychology, 39*(1), 67–71. http://dx.doi.org/10.1177/0098628311430640.

Mayer, R. E. (2005). Principles for managing essential processing in multimedia learning: segmenting, pretraining, and modality principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 169–182). New York, NY: Cambridge University Press.

Mestre, L. S. (2012). Student preference for tutorial design: a usability study. *Reference Service Review, 40*(2), 258–276. http://dx.doi.org/10.1108/00907321211228318.

Michas, I. C., & Berry, D. C. (2000). Learning a procedural task: effectiveness of multimedia presentations. *Applied Cognitive Psychology, 14*, 555–575.
Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, UK: Oxford University Press.
Palmiter, S., & Elkerton, J. (1993). Animated demonstrations for learning procedural computer-based tasks. *Human-Computer Interaction, 8*, 193–216.
Payne, S. J., Chesworth, L., & Hill, E. (1992). Animated demonstrations for exploratory learners. *Interacting with Computers, 4*(1), 3–22.
Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education. Theory, research, and applications* (2nd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.
Plaisant, C., & Shneiderman, B. (2005). *Show me! Guidelines for recorded demonstration*. Paper presented at the 2005 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC'05), Dallas, Texas http://www.cs.umd.edu/localphp/hcil/tech-reports-search.php?number=2005-02.
Ploetzner, R., & Lowe, R. (2012). A systematic characterisation of expository animations. *Computers in Human Behavior, 28*, 781–794. http://dx.doi.org/10.1016/j.chb.2011.12.001.
Rheinberg, F., Vollmeyer, R., & Burns, B. D. (2001). FAM: Ein Fragebogen zur Erfassung aktueller Motivation in Lern- und Leistungssituationen. *Diagnostica, 47*(2), 57–66. http://dx.doi.org/10.1026//0012-1924.47.2.57.
Rieber, L. P. (1991). Animation, incidental learning, and continuing motivation. *Journal of Educational Psychology, 83*(3), 318–328. http://dx.doi.org/10.1037/0022-0663.83.3.318.
Spangenberg, R. W. (1973). The motion variable in procedural learning. *AV Communication Review, 21*, 419–436.
Tversky, B., Bauer-Morrison, J., & Bétrancourt, M. (2002). Animation: can it facilitate? *International Journal of Human-Computer Studies, 57*, 247–262. http://dx.doi.org/10.1006/ijhc.2002.1017.
van der Meij, H. (2000). The role and design of screen images in software documentation. *Journal of Computer Assisted Learning, 16*, 294–306.
van der Meij, H. (2008). Designing for user cognition and affect in a manual. Should there be special support for the latter? *Learning & Instruction, 18*(1), 18–29.
van der Meij, H. (2014). Developing and testing a video tutorial for software training. *Technical Communication, 61*(2), 110–122.
van der Meij, H., Blijleven, P., & Jansen, L. (2003). What makes up a procedure? In M. J. Albers, & B. Mazur (Eds.), *Content & Complexity. Information design in technical communication* (pp. 129–186) Mahwah, NJ: Erlbaum.
van der Meij, H., & Gellevij, M. R. M. (1998). Screen captures in software documentation. *Technical Communication, 45*(4), 529–543.
van der Meij, H., & Gellevij, M. R. M. (2004). The four components of a procedure. *IEEE Transactions on Professional Communication, 47*(1), 5–14. http://dx.doi.org/10.1109/TPC.2004.824292.
van der Meij, H., Karreman, J., & Steehouder, M. (2009). Three decades of research and professional practice on software tutorials for novices. *Technical Communication, 56*(3), 265–292.
van der Meij, H., & van der Meij, J. (2013). Eight guidelines for the design of instructional videos for software training. *Technical Communication, 60*(3), 205–228.