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Effects of practice with videos for software training

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A B S T R A C T

This study investigated the contribution of practice in learning from Demonstration-Based Training (DBT) videos for software training. An experiment with three conditions is reported: practice followed by video (practice-video), video followed by practice (videopractice), and video only. The combination of practice and video was expected to enhance learning more than the video only condition. Also, practice-after was expected to be more effective than practice-before. The 82 participants, elementary students (mean age 11.2), achieved significant learning gains, reaching moderate to high levels of success on the immediate and delayed post-tests, and the transfer test. No practice effect was found. Also, there was no difference in test performance between practice conditions. The discussion advances several options for enhancing the effectiveness of the DBT-videos.

1. Introduction

Instructional videos (videos, from here on) for software training are becoming commonplace. Software companies such as Adobe, IBM, Microsoft, SAP, and TechSmith are offering more and more videos on their websites. These videos usually consist of a recorded demonstration – a screen capture animation with narration. Beyond that, though, little is known about the design characteristics and effectiveness of the videos produced by these companies. When using such videos to provide a tutorial for an audience of novices, the videos must generally accomplish two goals. One objective is to support task performance; the videos must enable or guide the user's task completion. Their other role is to support learning; the videos must instruct the user so that he or she can acquire the capability to perform trained and related tasks independently (Grabler, Agrawala, Li, Dontcheva, & Igarashi, 2009; van der Meij, Karreman, & Steehouder, 2009).

Design of videos should be oriented toward achievement of both of these goals. Recent research on software training has proposed and tested a theoretical model for video construction that combines Demonstration-Based Training (DBT) and multimedia learning theory (e.g., Brar & van der Meij, 2017; van der Meij & van der Meij, 2016a; van der Meij, 2017). The videos in these studies illustrate and explain the stepwise progression involved in task completion. That is, each video shows a single, menu-based method for completing the given task. That demonstration is enhanced with instructional features that support four key observational learning processes, namely, motivation, attention, retention, and (re)production. The inclusion of practice to support the (re)production process is important for the goal of learning, but its contribution has rarely been empirically investigated. It is the focus of this paper.

The present study investigates the influence of the presence and timing of practice on task completion and learning in video-based software training. Because very few studies have investigated the inclusion of practice in such training, we begin with a review of the research on practice in the related field of worked examples and then review practice in videos for software training. After that, we introduce and report an experiment with varying practice conditions in video-based software training.

2. Worked-examples research and the presence and timing of practice

The design of DBT-based videos for software training bears great similarity to the design of worked examples, which have a long and

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successful tradition in the development of problem-solving skill, usually in the domain of science (e.g., Atkinson, Derry, Renkl, & Wortham, 2000; Renkl, 2014; Salden, Koedinger, Renkl, Aleven, & McLaren, 2010; Sweller & Cooper, 1985; van Gog & Rummel, 2010). A worked example draws students' attention to key features in a problem and provides them with domain- or task-specific information. In other words, a worked example presents an ideal model that gives a step-by-step explanation of problem solving.

Many worked-example designs have a classic coupling of instruction and practice, with the former preceding the latter; students first receive procedural instructions (the worked example) about a topic and then engage in practice on a similar problem. In worked-examples research, the contribution of practice to learning has become a topic of systematic investigation (e.g., Leppink, Paas, van Gog, van der Vleuten, & van Merriënboer, 2014; Reisslein, Atkinson, Seeling, & Reisslein, 2006; van Gog, Kester, & Paas, 2011).

Worked examples research has advanced several arguments for including *practice-after giving instructions*. One reason is that practice-after can deepen understanding. Exercises, problems, or tasks given after the worked example stimulate students to construct meaning. A risk of worked examples is that they offer convenient directions that may invite passive and superficial processing (Atkinson et al., 2000). When students do not reflect on the examples sufficiently, the effectiveness of the examples is seriously threatened. The inclusion of practice-after can stimulate such reflective activities.

Another reason is that practice-after can consolidate learning. After having seen the modelled performance, practice serves as a check of understanding. The worked example provides students with a mental model of the solution process which can then be consolidated by practicing with a similar problem (van Gog, 2011).

Empirical studies have generally supported the claim that practice-after effectively increases learning of novices. Reisslein et al. (2006) found that low prior knowledge participants did better with practice-after and high prior knowledge participants did better with practice-before for worked examples on problem solving in electric circuits. Wouters, Paas, and van Merriënboer (2010) examined the role of practice of trained and transfer tasks with an animated model for problem solving in probability calculus. They compared practice-after, practice-before, and restudy of the worked examples and found no differences between conditions. The absence of the predicted advantage of the practice-after condition was explained by the fact that the participants in the study had relatively high prior knowledge. van Gog et al. (2011) compared example only, practice only, example with practice-after, and example with practice-before for four electrical circuit troubleshooting tasks. The findings on an immediate post-test showed significantly higher scores for the example only and practice-after conditions than for the practice only or practice-before conditions. No difference was found between the example only and practice-after conditions. Leppink et al. (experiment 2, 2014) replicated these findings for two application tasks on Bayes' theorem in statistics.

The prevalent argument for including *practice-before instructions* concerns a certain condition for learning, namely, the level of prior knowledge. When students have high prior knowledge, they may benefit more from an opportunity for exploration or orientation before receiving instructions. One reason is that these activities stimulate students to make connections between known and new information (Kalyuga, 2007).

Another argument in favor of practice-before instructions is that such a sequence is more motivating. Practice stimulates students to think hard about a problem. In turn, this also motivates them to process the subsequent worked example more deeply (Stark, Gruber, Renkl, & Mandl, 2000).

Only a few empirical studies have investigated the relative effectiveness of practice-before instruction. The studies by Reisslein et al. (2006) and Wouters et al. (2010) were discussed earlier. In addition, Paas (1992) found that participants in a worked examples only condition had significantly higher scores compared to practice-before on trained and transfer items concerning problem solving in statistics. In a study on Computer-Numerically-Controlled machinery, Paas and Van Merriënboer (1994) also found higher transfer test scores for the examples only condition. In contrast, Stark et al. (2000) predicted and found a stimulating effect of practice-before. Their experiment on computing interest rates showed a carry-over effect from one to the next of five successive practice-example pairs.

Overall, the findings from systematic research on the role of timing of practice in worked examples have been slightly mixed. Most studies with novices have found that practice-after is more effective for learning than practice-before, the exception being the study by Stark et al. (2000). Several studies have also found that example only study was equally as effective as practice-after.

3. Practice in videos for software training

To our knowledge, only Ertelt (2007) has studied the role of practice in video-based software training. We have therefore also included in our review of the empirical literature two (older) studies that we found on video-based instructions for assembly tasks, because such instructions set out to achieve a similar type of learning outcome as in software training.

Hannafin and Colamaio (1987) examined the influence of *practice-after* instructions for a 30-min video on a resuscitation apparatus. They found no improvement in task performance from the inclusion of practice-after. To account for the absence of an effect of practice, the authors postulated that participants engaged in a "form of vicarious mental rehearsal" that made "overt practice in the procedure unnecessary" (p. 210). Baggett (1988) also found no effect of practice-after. Her study compared a video-only with a video with practice-after condition for a set of Fischer-Technik assembly instructions. She suggested that the video alone sufficiently facilitated learning by enabling the participants to "imagine the (correct) movement" (p. 496). Ertelt (experiment 2, 2007) found a significant but small positive effect of practice-after on learning from a video for software training. It was suggested that the inclusion of practice had a motivating effect on the students.

We were unable to find any experiments involving video-based software training that manipulated the presence of *practice-before*. The absence of such studies is somewhat surprising considering the fact that users frequently consult software videos after having tried and failed to complete a software task (van der Meij et al., 2009).

4. Experimental design and research questions

The present study was set up as a quasi-experimental design with random allocation of participants within classrooms to conditions. There were three conditions: (1) Practice-video, (2) Video-practice, and (3) Video. The first two conditions combined watching the video with hands-on practice, the only difference being their sequencing. Participants in the practice-video condition first tried to complete a practice task themselves before receiving video instructions for that task, whereas participants in the video-practice condition followed the reverse order. Participants in the third condition only watched the videos. Learning was assessed with performance tests that required completion of tasks that differed from the demonstrated tasks in superficial features only.

Information on personal characteristics (e.g., gender, age, and prior task experience) was collected before training. The participants'