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Empirical study

Gaining from explaining: Learning improves from explaining to fictitious others on video, not from writing to them

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A B S T R A C T

Two experiments investigated whether studying a text with an “explanation intention” and then actually explaining it to (fictitious) other students in writing, would yield the same benefits as previously found for explaining on video. Experiment 1 had participants first studying a text either with the intention to explain it to others or to complete a test, and subsequently restudying vs. explaining in writing. Neither study intention nor explaining affected learning outcomes. Experiment 2 directly compared explaining in writing and on video. Participants studied a text with a test intention followed by restudy, or study with an explanation intention followed by either explaining in writing or on video. Explaining on video, but not in writing, enhanced learning more than restudy. These findings suggest that the benefits of explaining on video are not a result of engaging in explanation per se. Results are discussed in light of feelings of social presence.

1. Introduction

It is well established that explaining is a powerful learning strategy (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Fiorella & Mayer, 2015a, 2015b; Leinhardt, 2001; Lombrozo, 2012; Ploetzner, Dillenbourg, Preier, & Traum, 1999; Richey & Nokes-Malach, 2015; Wylie & Chi, 2014). Most research on the effects of explaining has focused on explaining instructional materials to oneself (i.e., *self-explaining*) or explaining to others in *interactive tutoring* situations (Ploetzner et al., 1999; Richey & Nokes-Malach, 2015). Recent studies, however, have shown that providing explanations of learned material to *fictitious* other students (i.e., not present, no interaction) is also effective for learning, and even more so than restudying that material (Fiorella & Mayer, 2013, 2014; Hoogerheide, Loyens, and Van Gog, 2014a).

Hoogerheide et al. (2014a) provided students with a text on syllogistic reasoning problems. Students who were instructed to study with the intention to explain the learning material to someone else and then explained it to a fictitious other student by creating a webcam video showed higher learning and transfer performance on an immediate and delayed posttest compared to students who were instructed to study with the intention of performing well on a test and engaged in restudying the material, which is how students normally study. The cognitive schemas acquired by those who explained on video were also more efficient in the sense that higher test performance was attained with equal (perceived) effort investment on the posttest (for elaboration on instructional efficiency in terms of the relation between mental effort and performance, see Van Gog & Paas, 2008). This pattern of results was found across two experiments. In the second experiment, students in the restudy condition engaged in a recall activity prior to restudy to rule out the possibility that the positive effects of explaining on video were simply caused by retrieval practice (inherent to explaining), which has been shown to positively affect learning outcomes (Roediger, Putnam, & Smith, 2011).

Fiorella and Mayer (2013, 2014) obtained similar results in two studies on the effects of studying with the expectation of teaching later on (i.e., a teaching expectancy) and actually teaching by creating a short five-minute video lecture. Their participants studied a text about the Doppler effect. Across both studies, those students who expected to have to teach later on showed enhanced performance on an immediate but not on a delayed comprehension test compared to those studying for a test. Only the students who had actually created a video lesson showed better comprehension scores than those studying for a test on both the immediate and delayed comprehension test. Fiorella and Mayer also explored effects on (perceived) effort investment during learning. They

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found some tentative indications that studying with a teaching expectancy is more effortful than studying with a test expectancy. However, findings were mixed, possibly because effort investment was measured at the end of the experiment rather than directly after the learning phase.

Roscoe and Chi (2008) contrasted explaining learning materials to a fictitious peer student on video (i.e., creating a video lesson) to self-explaining and peer tutoring. In a first session, university students studied a text about the human eye (1025 words) for 30 minutes. One week later, in a second session, they generated explanations for 30 minutes with the materials still being available (at least in the peer tutoring and self-explaining conditions). Although all three strategies were beneficial for learning, explaining on video was less effective relative to peer tutoring and self-explaining. It is unclear how these findings relate to Fiorella and Mayer (2013, 2014) and Hoogerheide et al. (2014a), however. Next to self-explaining and peer tutoring being stronger control conditions than restudy, Roscoe and Chi's study had a very different design (i.e., a delay between sessions, materials available during explaining, the time spent on explaining), and the actual time spent explaining in the three conditions was not reported and therefore may have differed among conditions.

Regardless of what exactly caused explaining on video to be less effective than self-explaining and peer tutoring, the positive effect found by Fiorella and Mayer (2013, 2014) and Hoogerheide et al. (2014a) beg the question of whether there is something specific to the video creation process that promotes learning, or whether it is simply the fact that students engage in explaining that causes beneficial effects on learning outcomes. In case of the latter, one would expect no unique benefit from explaining on video compared to explaining in writing. Instructions to provide written explanations for others would also be easier to implement in the classroom. Therefore, Experiment 1 replicated and extended the study by Fiorella and Mayer (2013, 2014) and Hoogerheide et al. (2014a) by having students explain in writing instead of on video. Experiment 2 made a direct comparison between explaining on video versus explaining in writing. Before introducing the experiments in more detail, we will first review relevant literature on the effects of study intention and teaching expectancy, as well as on the effects of giving explanations on learning outcomes.

1.1. *Effects of studying with the intention to explain*

Studying learning materials with the intention of explaining them to others later on, also referred to as 'teaching expectancy', can be expected to foster effective study processes. For example, studying with an explanation intention may stimulate more active processing (Benware & Deci, 1984), comprehension monitoring (e.g., asking oneself "why" questions; Roscoe, 2014), self-explaining (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Chi, De Leeuw, Chiu, & LaVancher, 1994; Renkl, 1997, 2002), metacognitive processing (Muis, Psaradellis, Chevrier, Leo, & Lajoie, 2015), and generating deep questions and explanations (Craig, Gholson, Brittingham, Williams, & Shubeck, 2012; Craig, Sullins, Witherspoon, & Gholson, 2006).

Research on studying with a teaching expectancy has led to mixed findings, however. Some studies found positive effects on learning outcomes. For example, in Bargh and Schul (1980), the university students who studied a passage with a teaching expectancy outperformed those who studied with a test expectancy on a subsequent recall and recognition test. Similarly, Nestojko, Bui, Kornell, and Bjork (2014) recently showed that university students recalled more information from a text and recalled more efficiently if they had studied the text with a teaching expectancy. This benefit was also found, albeit less consistently, on the short answer test. Muis et al. (2015) even found that for primary school children, studying with a teaching expectancy fostered the use of metacognitive strategies and learning outcomes. Other studies did not find such positive effects on learning outcomes, however. For example, Renkl (1995) showed that studying learning materials with a teaching expectancy evoked university students to study less superficially than those who studied with a test expectancy, but this did not result in higher learning outcomes. Those who studied with a teaching expectancy even showed less intrinsic motivation and increased levels of anxiety. Higher anxiety was also found by Ross and DiVesta (1976). Finally, Ehly, Keith, and Bratton (1987) found a detrimental effect of teaching expectancy in the sense that high school students performed worse on a test if they studied with a teaching expectancy than if they studied for a test.

Several explanations have been offered for the mixed findings. Regarding immediate vs. delayed tests, Fiorella and Mayer (2013, 2014) suggested that the effect of studying a text with the intention of explaining it later on might be short-lived. On a delayed posttest, this effect would have diminished unless the expectancy had been coupled with actually explaining (on video). However, other studies did not even find beneficial effects of teaching expectancy on an immediate posttest (e.g., Ehly et al., 1987; Renkl, 1995). A potential explanation for the differences in findings with regard to immediate test performance could be that learners might need a certain level of experience with studying with an explanation expectancy before it becomes beneficial for learning. In the study by Hoogerheide et al. (2014a), no effects of an explanation intention were apparent for secondary education students. For university students in a problem-based learning curriculum, who are used to explaining to other students, the explanation intention did positively affect learning both on the immediate and the delayed posttests. Note however that Muis et al. (2015) showed that even primary school children could benefit from studying with a teaching expectancy, and it would seem unlikely that they would have had a lot of experience explaining to each other.

1.2. *Generating explanations*

Generating explanations can be a powerful method for improving learning outcomes (Dunlosky et al., 2013; Fiorella & Mayer, 2015a, 2015b; Leinhardt, 2001; Lombrozo, 2012; Ploetzner et al., 1999; Richey & Nokes-Malach, 2015; Wylie & Chi, 2014). As mentioned above, research on generating explanations has mainly focused on the effects of self-explanations and the effects of explaining to others in tutoring or collaborative learning contexts (Ploetzner et al., 1999; Richey & Nokes-Malach, 2015). As Richey and Nokes-Malach (2015) describe, research on self-explaining has shown that:

> '… encourage learners to identify and elaborate on the critical features of problems, including the underlying principles (Atkinson, Renkl, & Merrill, 2003; Chi & VanLehn, 1991), the conditions for applying those principles (Chi et al., 1989), and the logic and subgoals for applying them (Catrambone, 1998; Crowley & Siegler, 1999). These critical features tend to apply across problems within a domain. By recognizing and understanding these features, a learner is more likely to successfully transfer knowledge to a novel problem (Atkinson et al., 2003).' (p. 203)

These cognitive benefits may in part arise because the process of self-explaining may stimulate metacognitive processes such as monitoring the quality of one's own understanding (i.e., comprehension monitoring; Roscoe & Chi, 2007). However, a caveat to self-explaining is that students may not always generate high quality self-explanations on their own (e.g., Renkl, 1997), and therefore may need self-explanation prompts (e.g., Nokes, Hausmann, VanLehn, & Gershman, 2011) or even an explicit training (e.g., Kurby et al., 2012) before generating self-explanations effectively.

Explaining to others has also been shown to enhance learning outcomes in interactive situations, for instance when tutoring (Cohen,