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The role of co-explanation and self-explanation in learning from design examples of PowerPoint presentation slides

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ABSTRACT

The current study investigated how people learn design principles from examples of PowerPoint presentation slides through self-explanation and co-explanation. This study also explored a strategy to improve the effectiveness of co-explanation by integrating it with a collaborative design activity. Pre-service teachers ($n = 120$) studied the design examples of PowerPoint presentation slides in four research conditions: co-explanation with design, co-explanation, self-explanation, and no prompt (control). Pairs of learners in the co-explanation condition explained fewer strengths and weaknesses of the design examples than nominal pairs in the self-explanation condition. Moreover, co-explanation was not more effective than self-explanation when it came to individual learning outcomes. In contrast, pairs in the co-explanation with design condition were more actively engaged in co-explaining design examples than pairs in the co-explanation condition. This study shows that co-explanation with design is more beneficial for constructing and sharing knowledge of design principles than co-explanation only. This study discussed a trade-off between constructive/interactive learning effects and transactional activity costs in co-explaining design examples.

1. Introduction

Multimedia materials are frequently used for learning and teaching in 21st century classrooms. Despite the affordances of multimedia technologies in education, ineffectively designed multimedia materials increase extraneous cognitive load and hinder knowledge construction (Mayer & Moreno, 2003; Sweller, 2010). For instance, PowerPoint presentation slides that include too many texts per slide or pictures unrelated to the learning content may be detrimental to meaningful learning (Bartsch & Cobern, 2003; Savoy, Proctor, & Salvendy, 2009). Szabo and Hastings (2000) also found that PowerPoint lectures were not always more beneficial for learning than traditional lectures. The effectiveness of PowerPoint lectures may depend on the design of PowerPoint presentation slides as well as tasks and individual differences. For the development of effective PowerPoint presentation slides as multimedia instructional materials, teachers should conceptually understand design principles regarding what makes high- or low-quality presentation slides. In diverse domains, literature shows that a conceptual understanding of principles and examples promotes development of procedural knowledge and problem solving skills (Anderson, Fincham, & Douglass, 1997; Renkl & Atkinson, 2003; Rittle-Johnson, Siegler, & Alibali, 2001). To facilitate an in-depth understanding of design principles on multimedia instructional materials, the present study investigates example-based learning in which learners identify and explain design principles from product-oriented examples (van Gog, Paas, & van Merriënboer, 2008) of PowerPoint presentation slides. These examples are referred as *design examples* in the current study.

Example-based learning is an effective and efficient method for knowledge construction of novice learners (Atkinson, Derry, Renkl, & Wortham, 2000; Paas & Van Gog, 2006). A number of studies on example-based learning have revealed that self-explanation (i.e., explaining the meanings of learning materials such as worked examples to oneself) is an effective strategy to integrate new information with existing knowledge and to repair faulty knowledge (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Nokes, Hausmann, VanLehn, & Gershman, 2011; Renkl, Stark, Gruber, & Mandl, 1998; Rittle-Johnson, 2006; Schworm & Renkl, 2007). However, self-explanation may be

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ineffective or hinder meaningful learning when novice learners have difficulty in recognizing their invalid explanations. For instance, Kuhn and Katz (2009) found that self-explanation hindered novice learners from generating valid causal explanations from scientific data. Self-explanation might aggravate interpreting data from prior faulty conceptions and beliefs.

As an alternative, an instructor can have learners collaboratively explain (i.e., *co-explain*) worked examples because pairs of novice learners can construct a deeper understanding through collaborative discussions of their different viewpoints (Hausmann, van de Sande, & VanLehn, 2008; Schwarz, Neuman, & Biezuner, 2000; Shirouzu, Miyake, & Masukawa, 2002). Based on empirical studies, Chi (2009) argues that interaction with peers may be more beneficial for learning gains than passive, active, or constructive activities when all learning partners substantially contribute to collaborative tasks. However, few studies have been conducted to compare co-explanation with self-explanation and to seek for a way to enhance the effectiveness of co-explaining examples.

2. Co-explanation versus self-explanation

Through active interaction with peers, individuals can share diverse perspectives, collaboratively build knowledge, and generate new strategies and solutions that would not be observed when they work alone (Chi, Roy, & Hausmann, 2008; Jeong & Chi, 2007; Schwartz, 1995; Shirouzu et al., 2002). In the current study, co-explanation may allow learners to share their experience and knowledge of design principles of PowerPoint presentation slides and to identify more strengths and/or weaknesses of design examples from different perspectives, when compared to self-explanation in which learners work alone. However, the literature of collaborative learning does not always support the assertion that collaborative learning is superior to individual learning, and the effectiveness of small-group learning is varied depending on how learners actually interact with each other (Barron, 2003; Johnson & Johnson, 2009; Kirschner, Paas, & Kirschner, 2009).

From previous studies on collaborative learning and peer interaction, three hypotheses are identified in pertaining to the effectiveness of co-explanation versus self-explanation. First, the *productive interaction* hypothesis predicts that co-explanation will be more effective than self-explanation because individuals spontaneously contribute to reasoning of their learning partners and build a shared mental model in a small group while co-explaining examples. Several studies showed that pairs of students more effectively discovered principles or learned by observing each other than students working alone even though no instructional support was provided to promote productive interaction (Chi et al., 2008; Okada & Simon, 1997; Schwartz, 1995; Shirouzu et al., 2002). For instance, Okada and Simon compared pairs of learners with single learners in regard to discovering scientific principles from simulated experiments in a computer micro-world. They found that real pairs more entertained hypotheses and justified them for discovery than nominal pairs of single learners. As a result, real pairs outperformed nominal pairs in discovering scientific hypotheses.

In addition, Shirouzu et al. (2002) found that pairs of learners solved a mathematics problem in a more flexible way than single learners. Pairs frequently exchanged their roles of a task-doer and a monitor, and the monitor tended to provide different interpretations of what the task-doer carried out to solve a problem. Various solutions and trials between learning partners contributed to construction of knowledge that would be applied to different problems. Consistently, Schwartz (1995) found that pairs of learners constructed more abstract problem solving representations, which could be applied across multiple contexts, than individuals. Pairs tended to construct an abstract and common representation in order to coordinate and negotiate their different perspectives on a problem. These studies support the productive interaction hypothesis and explain why collaborative learning activities are more effective than individual ones. However, these studies have been conducted in the context of problem solving, and few studies have been conducted to examine the effectiveness of collaboration in example-based learning.

Second, the *unproductive interaction* hypothesis indicates that novice learners may not interact with peers in a productive way unless instructional support is provided. If learners do not actively interact with peers, the benefits of co-explanation may not be different from those of self-explanation. For instance, Craig, Chi, and VanLehn (2009) found that collaboratively observing video clips of an expert's problem solving process, which played a role of worked examples, was not superior to individually observing them when it came to learning gains and transfer of knowledge. Chi (2009) argued, "the set of processes each speaker in a dialog might undertake is no different than the processes that a learner might undertake while being constructive alone" (p. 86). In addition to the constructive process, peer interaction promotes comparing different perspectives, gaining a new insight, asking deeper questions, and sharing mental models. However, these advantages will be minimal if learners passively interact with learning partners.

Roscoe and Chi (2008) found that peer tutors who explained the content of a text about human eyes to the other student did not gain a deeper understanding than self-explainers who explained the meaning of the text aloud to themselves. Peer tutors generated significantly more knowledge-telling episodes in which learners merely paraphrased the text without elaboration and reasoning when compared to self-explainers. By contrast, self-explainers were more engaged in knowledge building activities to elaborate concepts with examples or analogies, make a connection with prior knowledge, and generate inferences from the text than peer tutors. The proportion of knowledge-building episodes had positive relationships with factual recall and text comprehension. Consistently, previous studies have shown cases of unproductive collaboration and emphasized that instructional support is necessary for productive collaboration (Barron, 2003; Johnson & Johnson, 2009; Sweller, 2010; Weinberger, Ertl, Fischer, & Mandl, 2005).

Lastly, the *cognitive load* hypothesis predicts that co-explanation can interfere with learning from examples. Co-explanation requires learners to combine and coordinate their explanations, which may increase cognitive load and prevent knowledge construction (Kirschner et al., 2009). According to the cognitive load perspective, collaborative learning has both positive and negative aspects for knowledge construction. In collaborative situations, intrinsic cognitive load associated with a learning task can be divided across group members, which enables groups to carry out a complex task more efficiently than individuals (i.e., *distribution advantage*). However, for a simple task, *transactional activities* such as discussing ways to exchange information and share tools may be deleterious to learning because transactional activities are seldom related to schema construction (Kirschner, Paas, Kirschner, & Janssen, 2011). That is, distribution advantages in collaborative learning can be offset by extraneous cognitive load imposed by transactional activities, especially in a simple task like example-based learning.

Kirschner and her colleagues compared individual learning with collaborative learning in two learning contexts, studying examples and solving problems. They found that collaborative learning is more efficient for learning by solving problems, but less efficient for learning by studying worked examples when compared to individual learning. The cognitive load caused by transactional activities may be more