Learning and Instruction xxx (2017) 1–12

Contents lists available at ScienceDirect

Learning and Instruction

journal homepage: www.elsevier.com/locate/learninstruc

Manipulating cognitive engagement in preparation-to-collaborate tasks and the effects on learning

Rachel Lam [a, b, *], Kasia Muldner [a, c]

[a] Arizona State University, Department of Psychology, 1151 S. Forest Ave, Tempe, AZ 85257, USA
[b] National Institute of Education, Learning Sciences Lab, 1 Nanyang Walk, Singapore 637616, Singapore
[c] Carlton University, Institute of Cognitive Science, 2201 Dunton Tower, 1125 Colonel By Drive, Ottawa, ON K1S 5B6, Canada

ARTICLE INFO

Article history:
Received 13 January 2015
Received in revised form 26 April 2017
Accepted 2 May 2017
Available online xxx

Keywords:
Preparation to collaborate
ICAP
Active versus constructive preparation
Active versus constructive collaboration

ABSTRACT

While collaborating with a peer can be highly beneficial for learning, more work is needed to understand how instructional activities in collaborative contexts should be designed so as to maximize learning outcomes. To address this, we investigated the impact of different types of preparatory and cognitively engaging tasks on learning from collaborating, using a 2×2 experimental study conducted *in situ* in four introductory psychology classes. We compared individual preparation versus no-preparation and "active" versus "constructive" tasks. A dyadic multilevel analysis showed that preparation prior to collaborating led to better deep learning outcomes, but that the type of preparation did not have a significant effect. We include an exploratory analysis of student dialogues during collaboration to further interpret our findings. We propose that a cognitively engaging preparation phase may lead to better learning because it encourages students to collaborate constructively even when the type of task does not elicit such engagement.

1. Introduction

Collaborating on a task has the potential to improve learning outcomes beyond working alone because collaboration affords opportunities to engage in various beneficial behaviors. These behaviors include explaining, questioning, comparing and contrasting perspectives, arguing and debating, elaborating, and generating ideas (Andriessen, Baker, & Suthers, 2003; Asterhan & Schwarz, 2009; Coleman, 1998; Engle & Conant, 2002; Hausmann, 2006; King, 1994, 1999, pp. 87–115; Kneser & Ploetzner, 2001), and consequently encourage reflection, recognition of knowledge gaps, integrating conceptions, and drawing inferences (Chi, 2000; Roschelle, 1992; Shirouzu, Miyake, & Masukawa, 2002; Teasley & Roschelle, 1993). However, simply placing a small group of students together in a classroom does not guarantee effective collaborative learning (Barron, 2003; Craig, Chi, & VanLehn, 2009; Dillenbourg, 2002; Gadgil & Nokes-Malach, 2012; Volet, Summers, & Thurman, 2009). Thus, to encourage students to capitalize on opportunities afforded by collaboration, researchers have examined the effects of various instructional interventions including collaboration skills training (Hausmann, 2006; King, 1990; Rummel, Spada, & Hauser, 2009), the provision of prompts or scripts to scaffold the collaborative process (Fischer, Kollar, Stegmann, & Wecker, 2013; Walker, Rummel, & Koedinger, 2011), and the design of tasks to elicit substantive discussions (Dillenbourg & Hong, 2008; Engle & Conant, 2002; Kapur & Bielaczyc, 2012). These interventions have been shown to improve collaborative learning to various degrees, confirming that students typically need support to collaborate effectively. However, the best ways to do that remains an open question.

The present study extends the existing work on the design of collaborative tasks and their impact on learning outcomes. In particular, we investigated the effects of different versions of collaborative task designs by implementing cognitive and preparatory task manipulations, without imposing structure or guidance on the collaboration process itself. The cognitive task manipulations were drawn from the Interactive-Constructive-Active-Passive (ICAP) framework to differentiate types of cognitive engagement in individual and collaborative activities. The preparatory task manipulations were inspired by the Preparation for Future Learning (PFL) paradigm to investigate the role that individual preparation

* Corresponding author. National Institute of Education, Learning Sciences Lab, 1 Nanyang Walk, Singapore 637616, Singapore.
E-mail addresses: rachel.lam@nie.edu.sg (R. Lam), kasia.muldner@carleton.ca (K. Muldner).

http://dx.doi.org/10.1016/j.learninstruc.2017.05.002

has on subsequent collaborative activities. However, our study differs from the traditional PFL model in several ways, as we describe after presenting the ICAP framework.

1.1. Interactive-Constructive-Active-Passive (ICAP)

The ICAP framework differentiates student engagement during learning activities according to students' overt behaviors and makes predictions about how different types of engagement impact learning. Thus, ICAP can be applied as an instructional tool to design tasks that elicit behaviors needed for effective learning. It is founded on theoretical assumptions about how four categories of overt behaviors (Passive, Active, Constructive, Interactive) link to cognitive processes. Briefly, Passive engagement refers to students attending to instructional materials without any physical activity (e.g., watching or listening silently to a teacher). The corresponding cognitive process is *storing* knowledge. Active engagement involves doing a non-generative physical activity while learning, such as copying a teacher's notes from the board or repeating definitions out loud. The cognitive process in this case is *emphasizing* or *selecting* knowledge. Constructive engagement involves generating inferences beyond the learning material, such as creating a concept map or explaining in one's own words. The underlying process is *creating* knowledge. Interactive engagement corresponds to participation in dialogues, such as two students discussing their ideas, and should facilitate the process of *co-creating* knowledge.

The ICAP hypothesis proposes that Interactive engagement will produce better learning outcomes than Constructive engagement, both producing better outcomes than Active engagement, all producing better outcomes than Passive engagement: I > C > A > P. These hypotheses are supported by various historical studies reviewed by Chi (2009), as well as by a recent empirical study by Menekse, Stump, Chi and Krause (2013). However, Menekse and Chi (2013) found that, contrary to the ICAP hypothesis, Interactive engagement was not always better than Constructive. To explain this discrepancy, students' "co-construction" was identified according to the number of ideas in their dialogues that could not exist without the contributions of both partners. The findings showed that students in the Interactive condition who engaged in more co-construction performed better than students in the Constructive condition, while those who were less co-constructive performed equal to or worse than those in the Constructive condition. Chi and Wylie (2014) now argue that students must be "*constructively*" interactive to reap the learning benefits of collaboration, with each collaborator contributing to the interaction, such as by offering up ideas, questions, feedback, explanations, elaborations, rebuttals, claims, reasons, or justifications for instance.

Other work has also found that Interactive engagement is not automatically better than Constructive. For example, Nokes-Malach, Meade, and Morrow (2012) found that non-experts did better working individually on a Constructive-type of aviation task compared to those who worked collaboratively (i.e., showing an inhibitory effect of collaboration). Asterhan and Schwarz' (2007) found similar conceptual gains between a dialogical argumentation group (i.e., two participants instructed to engage in argumentation) and a monological argumentation group (i.e., a single participant prompted with generic, neutral questions by a confederate that offered no additional domain-based content). Since the confederate in the monological condition was not *constructively* engaging, this could be considered Constructive rather than Interactive according to Chi's more recent characterization that collaborative participants should be *constructively* interactive. Finally, Deiglmayr's (2015) and Deiglmayr and Schalk's (2015) work has focused on the process of interaction during collaboration to show that both Constructive and Interactive types of engagement play important roles in learning from collaboration.

Our study contributes to the abovementioned work by using the ICAP framework to explicitly manipulate Active versus Constructive engagement during collaborative learning via the task design. In particular, students were instructed to *emphasize* and *select* knowledge (i.e. engage *actively* in the task) or to *create* new knowledge (i.e. engage *constructively*) while collaborating with a peer. Another goal was to explore the impact of preparation on learning outcomes within these two types of collaborative tasks. To investigate this aspect, we relied on foundations provided by the Preparation for Future Learning (PFL) paradigm.

1.2. Preparation for future learning (PFL)

The PFL paradigm explores how engaging in invention-types of tasks prepares students to learn better from a lecture (Schwartz & Bransford, 1998; Schwartz & Martin, 2004; Schwartz, Chase, Oppezzo, & Chin, 2011). Specifically, the invention task promotes a "readiness" for learning in part by encouraging students to generate, compare, and contrast a range of ideas and/or solutions in ways that make the underlying target features salient. Students can then learn better from a subsequent lecture because of the heightened awareness to these target features (Schwartz, Sears, & Chang, 2007). In general, PFL instructional strategies result in improved performance, especially on transfer problems, compared to tell-and-practice (Schwartz & Martin, 2004).

Our study is loosely based on the PFL paradigm in that we included a preparatory phase. The key difference between our work and the traditional PFL paradigm is what follows the preparatory phase. Given our interest in collaborative learning, we used collaboration as the subsequent learning activity instead of a lecture (or other form of direct instruction that presents the canonical representations of the concepts). While using collaboration as the activity following preparation is not part of the traditional PFL paradigm, it has some prior precedent. For instance, Froyd (2011) introduced a similar notion, albeit did not test the impact of doing so.

Historically, the notion of preparing for collaborating is not new, as Lyman and colleagues conceptualized the popular teaching strategy of "think-pair-share," where students first individually think about answers to questions, then discuss their ideas with a partner, and afterwards engage in a whole class discussion (Lyman, 1981; McTighe & Lyman, 1988). In addition, prior work has empirically shown the benefits of various forms of preparing before collaborating. Smith et al. (2009) found that students who first individually answered questions in a "clicker" lecture benefited from subsequently discussing their answer with a partner. Even when both partners could not answer the questions individually, their learning improved after discussion. Another area of research that has investigated how students can be prepared to collaborate is through use of collaborative scripts, showing that students generally benefit from additional scaffolding supports (see Dillenbourg & Hong, 2008, on macro scripts; and Fischer et al., 2013, on external scripts). This work typically mediates collaboration through educational technology, in contrast to our work, which involves face-to-face collaboration.

To investigate the impact of different types of preparation, we manipulated the type of preparation to be either Active or Constructive (which corresponded to the collaborative activity as being Active or Constructive, respectively). While prior work has not explicitly labeled preparation activities (or collaborative activities) as "Active" or "Constructive," recent studies have investigated different ways to prepare students to for learning in a future task based on cognitive engagement (Glogger-Frey, Fleischer, Gruny, Kappich, & Renkl, 2015; Holmes, Day, Park, Bonn, & Roll, 2014;