Designing Collaborative Learning Activities for Two Outcomes: Deep Structural Knowledge and Idea Generation

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Abstract: Four versions of a collaborative activity were designed by manipulating two factors: cognitive engagement and preparation to collaborate. The activities were implemented in real classrooms where students worked in pairs. Findings showed a benefit of preparation on deep knowledge, regardless of how students were instructed to engage. However, discourse data revealed that only students in the "constructive" engagement conditions generated ideas beyond the target concepts. The implications for classroom practices are discussed.

Introduction and Purpose

To extend the work on the Interactive-Constructive-Active-Passive (ICAP) framework and the Preparation for Future Learning (PFL) paradigm, this work drew from the theoretical assumptions of each model to investigate how a collaborative learning activity implemented in introductory psychology courses at a community college would impact deep understanding of concepts of memory. Both models support the notion that students will be more likely to acquire structural understanding of a topic (i.e. build more accurate mental models) when they have the opportunity to struggle with existing knowledge because it allows them to fill gaps and resolve inconsistencies in thinking (Chi, 2000; Schwartz, Sears, & Chang, 2007).

The ICAP framework differentiates how student overt behaviors link to underlying cognitive processes (Chi, 2009; Menekse, Stump, Krause, & Chi, 2013). For example listening to a lecture constitutes *Passive* engagement and aligns to the process of *storing knowledge*. Copying a teacher's notes from the board during the lecture makes engagement *Active*, linked to *assimilating knowledge*. To be categorized as *Constructive* engagement, students would have to *create knowledge* such as through generating explanations or questions in their own words. *Interactive* engagement links to *co-creating knowledge*, where discussion would lead to shared meaning. Since we know that students do not always interact effectively nor engage in dialogic behaviors that facilitate mutual meaning-making (Barron, 2003; Volet, Summers, & Thurman, 2009), researchers continue to search for ways to improve collaborative activities. The current study aimed to address whether collaborating on a *constructive* version of a task compared to an *active* version would improve student interactions to lead to deeper learning. In other words, would a task designed specifically to elicit *constructive* cognitive engagement help students to collaborate more effectively for learning?

The PFL paradigm offers a dual phase instructional model where students first "prepare" their knowledge through a difficult open-ended learning activity, and then consolidate knowledge through a "future" lecture (Schwartz & Bransford, 1998; Schwartz & Martin, 2004). For the current study, the same premise was used to create a collaborative task that could provide a preparation-of-knowledge period and a consolidation-of-knowledge period. In this case, students first worked on the task alone to prepare knowledge, then completed the task with a partner to consolidate knowledge through discussion. This aimed to address the question of how collaboration, rather than a form of direct instruction, could serve in the consolidation phase of a PFL model.
Thus, by using ICAP and PFL as instructional design tools, this work aimed to create a collaborative task that could present the opportunity to struggle with knowledge through *constructive* engagement during "preparation," and then to consolidate knowledge during "future" collaboration to lead to deep learning.

Methods

The study used an experimental design in authentic classroom settings, preserving internal validity by equally representing all conditions in each classroom and randomly assigning students to conditions and partners (N=90). It occurred over the course of one week and included a pretest to assess prior knowledge, the learning activity, and a posttest to assess structural knowledge. The students participated in the study as part of their regular curriculum, with the study activities replacing the instructors' original instruction for the topic of Memory. The learning materials were equivalent in content and time-on-task was equalized across conditions. The four conditions were as follows: Prep/Constructive, Prep/Active, No Prep/Constructive, No Prep/Active. In the Prep conditions, students worked on the task alone for part of the class and then completed the task with a partner. In the No Prep conditions, students worked jointly the entire time. In the Constructive conditions, students were asked to invent concepts after examining data from real-world experiment scenarios. In the Active conditions, students were given the concepts to study and then asked to apply them to the (same) real-world scenarios. Structural knowledge was measured by a posttest that required students to predict the results of new experiments based on the target concepts of the learning activity. Student work was scored using a rubric that was developed *a priori*. For a secondary analysis, a subset of student pairs were audio-recorded during the activity (N=15). These data were used to examine the ideas students generated throughout discussion.

Utterances were segmented and coded by content to separate single and distinct idea units (Chi, 1997). The number of target concepts and novel concepts (i.e. those not embedded in the learning materials) were recorded.

Results and Interpretations

A dyadic analytic technique was used to account for subject dependency to evaluate the structural knowledge outcomes. Contrary to the hypothesis that there would be an advantage of the *constructive* version of the task, students in both Prep conditions equally outperformed the No Prep groups by approximately a letter grade, $F(1,41.1)=5.79$, $p<.03$. Thus, it appears that collaboration can sufficiently replace lecture as a "future" task (with regard to PFL) but that the preparation need not be *constructive* (with regard to ICAP). However, there was an observable benefit of the *constructive* version of the task in the discourse data; only the pairs in the *constructive* conditions generated any novel ideas beyond the target concepts. Thus, the added benefit of interacting on a *constructive* compared to an *active* collaborative task that also includes a preparation period is that students are able to generate new ideas without impairing targeted learning. Findings are summarized below.

Table 1: Comparison of outcomes: deep knowledge and discussion of target versus novel concepts

	Posttest	Discourse	
Measured:	Deep knowledge	Target concepts	Novel concepts
Occurred:	After learning activity	During learning activity	During learning activity
Completed:	Individually	Collaboratively	Collaboratively
Instructional Conditions			
Prep/Constructive	$M = 75.00$	$M = 3.25$	$M = 3.50$
Prep/Active	$M = 76.17$	$M = 7.33$	$M = .0$
No Prep/Constructive	$M = 66.67$	$M = 4.00$	$M = 4.50$
No Prep/Active	$M = 61.17$	$M = 6.75$	$M = .50$
Total possible	100%	8 concepts	N/A
N	90 students	15 pairs	15 pairs

Discussion

This work tested four versions of a collaborative learning activity implemented in authentic classrooms to inform on the usability of combining two cognitive frameworks for instructional design. It extended the PFL model to show that preparation as individual work followed by collaboration as a future task can benefit deep learning. Future work will examine how collaboration compares to direct instruction in the consolidation phase. Although no differences in deep learning were detected between the *active* versus *constructive* tasks, this work expanded upon the ICAP framework to show that collaborating on *constructive* tasks leads students to generate novel ideas during discussion, whereas collaborating on *active* tasks limits discussion to the concepts explicitly stated in the learning materials. With regard to instructional practice, teachers can use these two cognitive frameworks together to design collaborative learning activities that both improve deep knowledge and facilitate idea generation during discussion.

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