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### Software-based scaffolding: Supporting the development of knowledge building discourse in online courses

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## Software-Based Scaffolding: Supporting the Development of Knowledge Building Discourse in Online Courses

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**Abstract:** This design-based research study investigated instructional scaffolding for knowledge building discourse among participants (n=17, n=20) in two online graduate courses. In particular, designs of software-based scaffolding as found in web-based Knowledge Forum's scaffold support feature were refined. Analyses of the student discourse data suggests that Knowledge Forum's scaffold supports offer a promising avenue for future design innovations to encourage knowledge building discourse. Results show that students increasingly used the scaffolds to focus their reading and writing of notes over iterations of the study. The proportion of scaffolds for knowledge building discourse increased during each iteration with a corresponding decrease in the proportion of scaffolds for expressing an opinion in the second iteration. Finally, notes with scaffolds contained significantly more words than notes without scaffolds, suggesting that scaffolds promoted more student reflectivity. Implications for formative assessment of student learning and knowledge building are discussed.

### Introduction

In recent years, opportunities to enroll in online courses have grown substantially. During the fall 2004 term, 2.3 million higher education students were taking at least one online course in the United States; one year later, during the fall 2005 term, this figure increased to nearly 3.2 million students (Allen & Seaman, 2006). The primary mode of online course delivery at nearly 90% of U.S. higher education institutions is asynchronous computer-mediated communication (CMC) (Greene, 2005). Asynchronous CMC typically uses a web-based computer conferencing technology (e.g., Blackboard, Drupal, Knowledge Forum, Moodle, etc.) to connect distributed participants in a networked learning environment. Like distance education, CMC frees students from time and space constraints; like face-to-face instruction, CMC affords interactivity (Kaye, 1989). Ideally, CMC is used to create a "the kind of learning community that can arise in a good graduate seminar" (Hiltz, 1998). In such educational settings, students may be able to engage in complex learning where they share, question and revise their ideas to deepen understanding and build knowledge.

Yet CMC is a lean medium for social presence crucial to perceptions of cooperation and trust necessary to build a learning community (Palloff & Pratt, 1999; Preece, 2000). Thus, widely accepted models for teaching in online learning communities focus first on establishing social connections between participants. For example, Salmon's (2000) five-stage model for "e-moderating" describes the progression of students as they move through the beginning stages of access and motivation, to online socialization, information exchange and knowledge construction, and ultimately to development. This model highlights the importance of the instructor's role in the earlier stages of creating an online learning community. Once a sense of community is established, the instructor shifts the locus of control to the students, who are then able to engage in active learning and collaboration (Palloff & Pratt, 1999).

This study departs from previous studies by focusing on higher goals for social interaction in online learning communities. Research indicates that critical thinking and knowledge construction rarely occur in these educational settings (Garrison, Anderson & Archer, 2001; Gunawardena, Lowe, & Anderson, 1997; Kanuka & Anderson, 1998). Previous studies on scaffolding dialogue for knowledge building have explored how certain critical thinking types increase or decrease the length of discussion threads (e.g., Sorenson & Takle, 2005). However this study takes an approach consistent with a knowledge building pedagogy (Scardamalia & Bereiter, 2003, 2006), rather than one informed by a critical thinking model. While many online studies have examined social interaction and collaboration, less is known about how instructors may move students to the next step and foster knowledge building discourse. Therefore, the purpose of this study is to investigate what kinds of scaffolding embedded in the software and course activity structures can support the development of knowledge building discourse in online graduate courses. As well, we argue that scaffolding is closely linked to formative assessment (c.f., Shepard, 2005) and that can activate students to take ownership over their learning (Black & Wiliam, 2009) in a way that is aligned with the knowledge building pedagogy.

## Theoretical Framework

Social constructivist pedagogy emphasizes the importance of discourse in fostering deep learning, and the importance of tools in mediating knowledge construction (Hmelo-Silver, 2003; Palincsar, 1998). Knowledge building is defined as “the production and continual improvement of ideas of value to a community” (Scardamalia & Bereiter, 2003, p. 1370). It is a constructivist approach that centers the curriculum on big ideas and accords students with high levels of agency in working with those ideas (Scardamalia & Bereiter, 2008).

Knowledge Forum, an extension of CSILE (Computer Supported Intentional Learning Environment) software, is designed to support knowledge building. Students work in virtual spaces or “views” to develop their ideas, represented as “notes.” Knowledge Forum offers sophisticated features not available in other conferencing technologies including “scaffold supports” (labels of thinking types), “rise above” (summary note), and a capacity to connect ideas through links between notes in different views. These features provide means to overcome the chronological sequence of threaded discussion, in which important ideas may be lost. In addition, Knowledge Forum facilitates the collection of data that are amenable to analysis with a variety of assessment tools. These include behavioral and interaction analyses (Burtis, 1998), traces of vocabulary development (Hewitt, 1999), social network analysis (Teplovs, Donoahue, Scardamalia, & Philip, 2007), and semantic analysis (Fujita & Teplovs, 2009). Such assessments provide feedback to help students make progress in their discourse.

Many studies on knowledge building discourse have examined elementary science classrooms (e.g., Hakkarainen & Palonen, 2003; Bereiter, Scardamalia, Cassells, & Hewitt, 1997). These show that CSILE/Knowledge Forum can support improved learning and knowledge building over time (Scardamalia & Bereiter, 1994; Zhang, Scardamalia, Reeve & Messina, 2009). However, few studies have explored how to support the development of knowledge building discourse in exclusively online higher education courses where the participants are distributed across time and space and instructional scaffolding for knowledge building is not provided off-line. The knowledge building teacher’s role in this setting is one that helps students move beyond the formation of social ties to the creation of knowledge. This study offers a unique perspective by refining designs of software-based scaffolding as found in Knowledge Forum’s scaffold support feature to foster knowledge building discourse in online graduate courses.

## Methods

Using a design research methodology (Collins, Joseph, & Bielaczyc, 2004), modifications to the selection of Knowledge Forum’s (KF) scaffolds were made within and across two 13-week online graduate courses, which comprised two iterations of the study (Table 1).

Table 1: Design Changes to Knowledge Forum’s Scaffold Across Two Online Graduate Courses

	Iteration 1	Iteration 2
Modification	Educational Applications of Computer-Mediated Communication	Constructive Learning and Design of Online Learning Environments
Knowledge Forum Scaffolds	Theory Building Opinion Idea Improvement Feedback	Theory Building Opinion Idea Advancement

KF scaffold supports are typically used as sentence openers that students use while composing notes in the database. They function in similar ways as prompts in social networking applications like Facebook (What’s on your mind?) or Twitter (What are you doing?) by placing yellow highlights of thinking types into the text that bracket segments of body text in notes. Scaffold supports go further than just prompting users at a generic level. They are customizable by facilitators and, in some cases, students. The two sets of scaffold supports that are supplied by default (“Theory Building” and “Opinion”) are more specific to knowledge building discourse and argument than the more generic prompts from Facebook and Twitter. Scaffold supports are not dissimilar to “tags” that are common in other Web 2.0 environments such as the collaborative bookmarking application known as “delicious”. An important difference between the simple tagging available through such sites and the scaffold supports in Knowledge Forum is the ability to tag specific parts of posts and thereby indicate with relatively high specificity and accuracy that part of the text that is being tagged. Moreover, advanced search capabilities in Knowledge Forum allow users to search for specified text within a specified scaffold support

(e.g. find all the “My Theory” supports that contain the word “constructivism”).

In Iteration 1, only Theory Building and Opinion scaffolds built in to Knowledge Forum were available to students at the beginning of the course. Later, in week 9 of 13 weeks, students took on the responsibility for designing the customized Idea Improvement scaffolds as part of their discussion leadership (Table 2). These scaffolds emphasize the knowledge building principle of improvable ideas key to knowledge building discourse. In addition the researcher introduced the customized Feedback scaffolds in week 10 to help students provide constructive feedback to each other.

Changes to the scaffolds from Iteration 1 to 2 resulted from analysis of the students’ learning journals. The design researcher and the instructor addressed students’ concerns for the constraint scaffolds imposed on creative thinking and interpersonal relationships were addressed by combining the Idea Improvement and Feedback scaffolds into Idea Advancement scaffolds in Iteration 2.

**Table 2: Knowledge Forum Scaffolds and Scaffold Supports Used in Iteration 1 and 2**

Scaffold Supports	Scaffolds			
	Theory Building	Opinion	IDEA IMPROVEMENT (all caps in original)	Idea Advancement
	My Theory	Opinion	IDEA ADVANCEMENT	Current statement of idea
	I need to understand	Different opinion	WHAT DO WE NEED THIS IDEA FOR	How idea is useful
	New information	Reason	PROBLEM/QUESTION	How idea could be advanced
	This theory cannot explain	Elaboration		Problems/limitations
	A better theory	Evidence		How could we test X?
	Putting our knowledge together	Example		This idea fits with

**Data sources**

Student discourse, online questionnaire responses, pre- and post-course assignments, and learning journals were collected from participants (n=17, n=20) in two 13-week graduate courses taught entirely online using Knowledge Forum (version 4.5.3). This study focuses on findings from the analysis of KF scaffold use in the discourse data.

**Results**

Using log file data accessed via the Analytic Toolkit built in to Knowledge Forum, this study found patterns in the students’ use of KF scaffolds that affected the development of knowledge building discourse. First, there was an overall increase in the total number of scaffolds used from Iteration 1 to Iteration 2, as shown in Table 3:

**Table 3: Frequencies of Knowledge Forum Scaffolds Used in two Online Graduate Courses**

Course	Theory Building		Opinion		IDEA IMPROVEMENT/ Idea Advancement		Total Number of Scaffolds		Total Number of Student Notes	
	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%
Course 1	128	42%	91	30%	87	28%	306	100%	907	100%
Course 2	167	36%	200	43%	98	21%	465	100%	1058	100%

Course 2 students used more total scaffolds than Course 1 students. Course 2 students also used more Opinion than the Theory Building or Idea Improvement scaffolds than Course 1 students. A Pearson chi square test showed a statistically significant difference between the two Iterations,  $\chi^2(2, N=771) = 14.46, p < .001$ .

**Relationship Between Use of Scaffolds and Types of Scaffolds Used**

To understand whether the types of scaffolds used in student notes changed over time within each course, the frequencies of different types of KF scaffolds used were calculated for the first third and last third of the course, excepting the first week and last week. These weeks were omitted because they were used as introductory and evaluation sessions. When calculated, this analysis showed that Course 1 students used all of the scaffold types more frequently in the last third of the course compared to the first third (Figure 1).

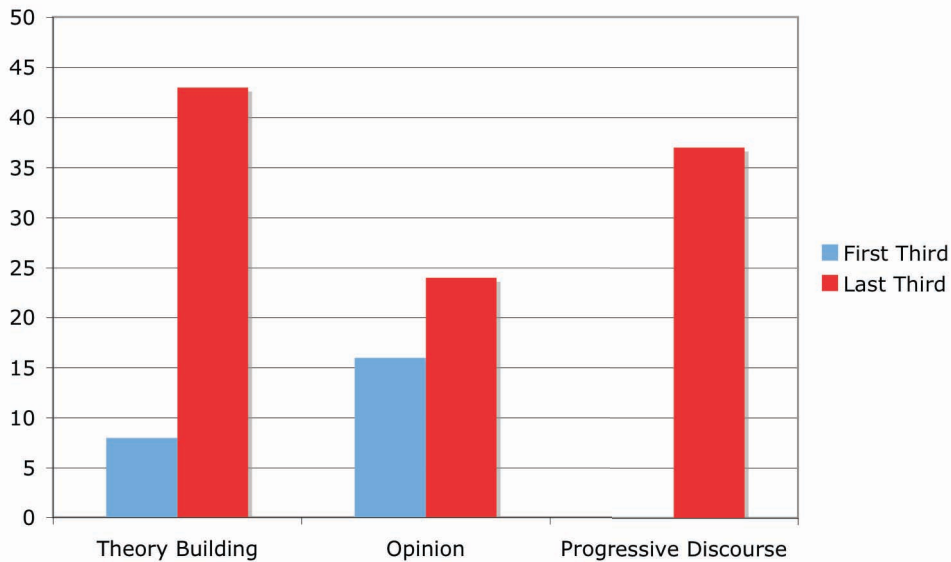


Figure 1. Types of Knowledge Forum scaffolds used by students in Course 1.

In comparison, all three types of scaffolds were available from the beginning of Course 2. Promisingly, the students' use of Theory Building and Progressive Discourse (Idea Improvement and Idea Advancement) scaffolds increased and their use of Opinion scaffolds decreased from the first third to the last third of the course (Figure 2).

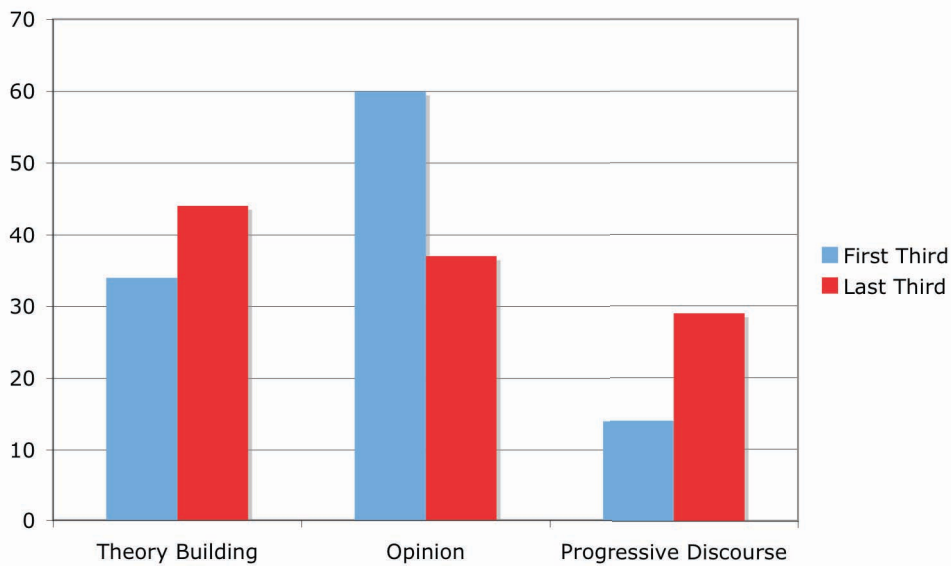


Figure 2. Types of Knowledge Forum scaffolds used by students in Course 2.

## Relationship Between Use of Scaffolds and Length of Notes

To understand the relationship between the use of KF scaffolds and length of notes, the mean word counts of student notes with scaffolds and without scaffolds were compared. A paired samples t-test found that notes with scaffolds contained significantly more words than notes without scaffolds,  $t(33)=3.626$ ,  $p<.001$ .

## Discussion

This design-based research study refined designs of software-based scaffolding as found in Knowledge Forum's scaffold support feature to foster knowledge building discourse in two online graduate courses. KF scaffolds not only metacognitively prompt students to focus their reading and writing of notes, but also allow them to tag relevant parts of notes and search for ideas to improve them. Such a feature offers students, not just teachers, the opportunity to take responsibility for accessing support as needed, customizing supports for local needs, and obtaining some formative assessment of the progress of the unfolding discourse to deepen their learning. Analyses of the student discourse data suggest that KF scaffold supports offer a promising avenue for future design innovations to encourage knowledge building discourse.

Finding that students used scaffolds for expressing opinions aimed at argument rather than scaffolds to support knowledge building discourse aimed at explanation was disappointing, but not surprising given the challenge of engaging students in this kind of discourse to promote complex learning online. Scaffolds can guide students in complex learning by structuring tasks, but they can also problematize tasks by making them more complex in the short term (Reiser, 2005).

Over time within course discussion spaces, however, students increasingly used customized scaffolds to support development of knowledge building discourse. In Iteration 2, students not only increased their use of scaffolds for knowledge building, but they also decreased their use of scaffolds for expressing opinions. This is a positive finding since using the Theory Building and Progressive Discourse scaffolds require students to take a more active role in regulating their own learning as well as providing constructive feedback to peers.

From a knowledge building perspective, a characteristic of a mature producer of knowledge is "disciplined creativity" (Scardamalia & Bereiter, 2003). KF scaffolds help students to organize their own thinking, writing, and reading of other's notes. This may promote disciplined practices for knowledge building discourse. Unfortunately, some students in this study (35% in Iteration 1; 25% in Iteration 2) did not like the "disciplined" aspect of creative knowledge work that scaffolds were designed to support and identified constraints scaffolds posed for creative thinking and identified usability issues.

Previous researchers (e.g., Hara, Bonk, & Angeli, 2000; Schrire, 2006) have suggested that the length of messages is one sign of the depth of online student interaction and reflection on course readings. This study found that student notes with KF scaffolds are longer than notes without them. Students might be reflecting more when they compose longer notes with scaffolds and thus more effectively engage in knowledge building discourse to advance knowledge in their online learning community.

## Conclusion

In this paper, we explored designs of software-based scaffolds and course activity structures that encourage their use to support the development of knowledge building discourse in online graduate courses. Through analyses of students' scaffold use, this study found the following trends in the students' use of the Knowledge Forum's scaffold support feature:

- an increase in the use of scaffolds over iterations of the study
- the proportion of scaffolds for knowledge building discourse increased during each iteration
- the proportion of Opinion scaffolds for argument decreased during the final iteration
- notes with scaffolds contained significantly more words than notes without scaffolds

The students appear to be taking greater responsibility for their own learning by customizing and using the KF scaffolds to make their online course contributions more meaningful. Qualitative analyses reveal that the graduate students use KF scaffolds to work towards common understanding in discourse, but need encouragement to expand the factual base and to test ideas to build knowledge (Fujita, 2009). Formative assessment that is embedded in the software and tightly coupled to the learning (Collins & Halverson, 2009) may help students overcome such barriers in knowledge building discourse. To this end, Knowledge Forum's assessment tools offer ongoing and formative feedback to students as well as teachers and researchers to enable them to deepen understanding of the unfolding discourse in the online learning community (Teplovs et al., 2007).

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