# Attention Guidance in Online Learning Conversations

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## Abstract

*This paper reports the unique value of two different modes of scaffolds, faded instructor-based and peer-oriented attention guidance, in online learning conversations. Drawing upon the instructional effectiveness and challenges of scaffolding, we present the design of three versions of an anchored discussion system: two versions with different modes of scaffolds and one regular version as a control condition. A total of 150 students distributed in three sections of a management information systems course participated in this study. We randomly assigned each section to one of the three software designs. The results demonstrate that both types of scaffolds focused students' attention to important information from text, which catalyzed deeper processing of important information. Moreover, we found that peer scaffold function facilitated a positive upward trend for the negotiation of differences in perspectives. These results indicate that attention guidance can support students to use instructional materials more constructively in online learning conversations.*

## 1. Introduction

The increasing complexities produced by knowledge-intensive and technology-oriented organizational projects create new challenges for information systems education. Collaborative learning encompasses a broad spectrum of didactical approaches that hold common educators' interests to allow and stimulate learners to interact, share, and actively, co-create meaning. As pointed out by Stahl [1], students can be engaged in collaborative learning at different levels and time-frames from small-groups to larger communities, similar to the way knowledge work is being done in the real world. Pedagogically, knowledge in collaborative learning develops by expressing persuasive arguments, interpreting peers' viewpoints, and negotiating meanings through justified rebuttals [2]. Thus, collaborative learning is a promising educational approach for preparing students to manage inter-professional expertise and collaborative construction of new knowledge in today's complex information systems projects.

Computer-supported collaborative learning (CSCL) systems can support students to create new knowledge in asynchronous online discussions with the availability and salience of their affordances [3]. The open source anchored discussion system developed by Van der Pol et al. [4] is an effective tool for helping students collaboratively process academic literature and organize their knowledge. The design of this CSCL system centers on an annotation functionality identified by Suthers [5] to tightly couple learning material and its related discussion. Building on the metaphor of common ground from Clark's contribution theory, Van der Pol et al. [4] demonstrated that the system at hand affords a more efficient and meaning-oriented collaboration than regular forum discussion. Next, Eryilmaz et al. [6] compared two versions of this system (one with annotation functionality, and one without it, both displaying the learning material side by side with its associated discussion in one window) with each other and with a regular forum discussion. Emanating from this systematic comparison, Eryilmaz et al. [6] reported that the online presence of the learning material supports sustained content-focused discussions. Moreover, the annotation functionality identified by Suthers [5] promotes complex patterns of collaborative knowledge construction activities and re-focuses the discussion when it digresses. Finally, Eryilmaz et al. [7] showed that the relevant annotation functionality reduces explicit coordination activities during collaborative processing of academic literature and thereby availing students more time and effort for demanding knowledge construction activities that positively associate with individual learning outcomes.

Despite the potential for learning, evidence has been limited, in part, because discussion threads that focus on central concepts, principles, and their interrelations from complex instructional materials have a tendency to die, leaving little opportunity for developing negotiated understanding of a subject

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matter [8]. This fundamental problem stresses that students may not deeply process important information from complex instructional materials in online discussions, which inhibits learning [9, 10]. Along this line, Hewitt [8] demonstrated that students gravitate to familiar (comfortable) topics and avoid challenging topics from complex instructional materials in order to meet online discussion requirements. According to Bétrancourt et al. [11], students' above mentioned tendencies induce a "shallow processing of the subject matter instead of a deeper and more demanding processing" (p.66). Under such circumstances, Kim and Hannafin [12] remarked that "students develop robust and oversimplified misconceptions that prove highly resilient to change" (p.412). These empirical studies underscore students' difficulties in productive use of instructional resources during anchored discussions, which can yield lower learning results. Therefore, merely providing instructional materials in anchored discussions is not enough for students to develop a deep understanding from those materials. Students' attention needs to be directed to the understanding of central concepts, principles, and their interrelations.

Given the limited body of empirical research on attention guidance in CSCL systems [13], the purpose of this study is to examine the unique value of two different modes of scaffolds, faded instructor-based and peer-oriented attention guidance, to advance collaborative knowledge construction in discussion threads that focus on important information from complex instructional materials. Thus, we consider the concept of scaffold as affordances of technology for directing students' attention to challenging concepts from complex instructional materials in an indirect way. For this purpose, we further developed the peer-oriented attention guidance functionality proposed by Eryilmaz et al. [14] and set up an experimental study with three types of anchored discussion: two versions with different modes of scaffolds and one regular version, without an attention guidance function as a control condition.

The organization of the paper is as follows. Section two introduces a theoretical background that compares faded instructor-based and peer-oriented attention guidance in the context of CSCL. Section three explains software designs to facilitate these two different modes of scaffolds in an open source anchored discussion system. Section four presents three research questions to evaluate the effectiveness of software designs. Section five describes the research methodology. Section six examines fine-grained quantitative and qualitative data to answer the research questions. Section seven discusses the results and draws conclusions.

## 2. Theoretical background

This section outlines our theoretical lens that provides the main departure point for the rest of the paper. We are interested in enhancing individual conceptual understanding of complex instructional materials in settings of collaboration (small [6] and large [7] groups). Our approach is derived by an epistemic view that reconciling inconsistencies and conceptual misunderstandings during collaboration leads to a re-structuring of existing knowledge. However, the key issue arising from this epistemic view is that there is no guarantee for these interactions to delve deep into central concepts and principles from complex instructional materials, which inhibits learning [15]. From these considerations, CSCL research on constructivist learning has repeatedly shown that students with low domain knowledge need conceptual guidance (directing attention to important perspectives) allowing them to build a profound understanding in complex domains [e.g., 16, 17]. We synthesized the recent and related literature to distinguish between two types of conceptual guidance: (1) faded-instructor based and (2) peer-oriented attention guidance to promote coherent discourse focused on important information from complex instructional materials.

The first type, faded-instructor based guidance, aims at providing assistance within the zone of proximal development (i.e., the gap between what a student can accomplish individually and what a student can accomplish with an instructor's assistance) when needed and fading the assistance in order to leave room for self-directed performance of the skills to be acquired. Fading instructor's guidance is a fundamental didactic principle that is widely used in a variety of didactical approaches, such as problem-based learning [17]. As pointed by Molenaar et al. [18], the utility of this form of scaffolding lies in frequent assessment of students' attention allocations, its interpretation (diagnosis), and calibration of guidance when needed. Thus, a central challenge with this type of scaffold is to introduce the support without destroying the exploratory and creative potential of collaborative knowledge construction [19]. Prior research in online discussions has demonstrated that such guidance can prevent students deviating from discussions that focus on main points, which supports favorable learning outcomes [14, 20]. Yet instructor's over-guidance runs the risk of restricting students (see Dillenbourg [21] for a critique of over scripting in CSCL). In line with this risk, prior research has demonstrated that instructor's over-guidance tends to decrease the length and frequency of students' contributions and interactions [22]. Thus, the instructor's guidance in CSCL must be carefully balanced. Once students have acquired the desired competencies the instructor's guidance becomes redundant and in some cases it may hinder the knowledge acquisition because students may rely too much on the instructor's expertise and authority [24]. Within the scaffolding paradigm, a cognitive line of argument for the necessity of fading is that without it, students do not internalize the desired competencies, and that fading forces them to practice their knowledge and develop the necessary skills to apply it in novel situations [13]. Although fading is considered important within the scaffolding paradigm, empirical research results on the effects of fading are sparse and inconclusive (see Bouyias and Demetriadis, [24] for a review).

The impetus for the second type, peer-oriented attention guidance, is to motivate students to negotiate a fit between perspectives by using contrasts to spark and sustain knowledge advancement on collaboratively decided important topics rather than depending on the instructor's guidance. This difference points to a scaffold role rotation from instructor to peers, which underscores the importance of using learning partners as resources [7, 14]. Recent studies have demonstrated that peer-oriented attention guidance is very suitable for promoting deep processing of text [25] and developing dialogical argumentation skills, which prepares students to manage today's complex issues in knowledge societies [26]. Along this line, Caldwell [27] found that students prefer receiving explanations from their peers because they use a more similar language than the instructor to explain the problems and solutions. Moreover, Trees and Jackson [28] showed that this interactivity allows instructors to assess students' understanding of learning materials, provide feedback to address domain-related misconceptions, and develop closer relationships with students. However, true collaborative knowledge building (discovering new knowledge together that no one yet possessed) is a difficult and demanding process that requires a high level of rational and constructive discourse. Research in CSCL warns of students' difficulties in building complete arguments, which comprise a claim supported by grounds and limited by qualifications [6, 26]. Thus, it is necessary to take into account the quality of student argumentation in CSCL. Based on this theoretical lens, we now turn our focus to facilitating, faded instructor-based and peer-oriented attention guidance in online learning conversations.

## 3. Software designs

We implemented three new versions of Van der Pol et al.'s [4] anchored discussion system developed by Eryilmaz et al. [14]. The interface design in all three versions creates a close coupling between the learning material and its related discussion by binding the two in a single window. At the heart of this close coupling lies Marginalia, an open source JavaScript program, which facilitates fine-grained annotation of HTML pages. Students can create annotations by highlighting a passage and then clicking on an annotation bar to the right of the learning material. Marginalia has two crucial features. The first feature distinguishes which discussion thread corresponds to which annotated passage by lighting up both elements in red when either element is under the mouse cursor. The second feature embeds a student's key idea for annotating a passage in direct context that elicited it by inserting a sticky message. The flipside of this interface design, as noted by Suthers [5], is that it may interfere with students' reading as the learning material becomes cluttered with sticky messages. To address this concern, we designed sticky messages to appear only under the mouse cursor. In sum, all three versions of the software promote contextual communication for deep processing of complex instructional materials. However, they differ on the nature of attention guidance functionalities as described below.

### 3.1. Faded instructor-based attention guidance functionality

The first version (Figure 1) consists of an instructor interface derived from Marginalia Javascript program. The key objective of this interface is to support the instructor in steering students towards main topics in complex instructional materials. This interface runs only on the instructor account and it works by an instructor highlighting a passage and then clicking on an importance bar to the left of the learning material. The importance bar increases the font size of the highlighted passage. Thus, the relative size of the font for each passage corresponds to its relative importance determined by the instructor based on the learning objectives of online discussion. Tag cloud research demonstrates that font size is an effective visual property to capture attention in an involuntary or obligatory fashion [29]. The cascading style sheet (CSS) of this system includes two font sizes: default and big. On the one hand, the default font size (10px) represents a medium level importance. On the other hand, the big font size (15px) represents a high level of importance (see the usability study reported in Eryilmaz et al. [14] for the identification of these font sizes).

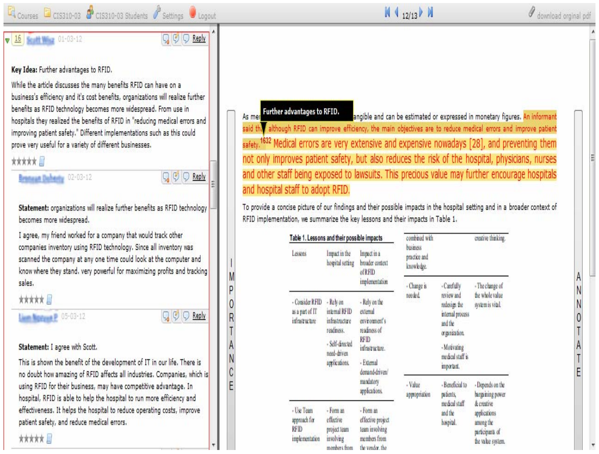

**Figure 1. Faded instructor-based attention guidance functionality**

## 3.2. Peer-oriented attention guidance functionality

The second version (Figure 2) tailors the aforementioned importance bar towards students in order to catalyze a negotiation process sparked by contrasting ideas on the importance of collaboratively decided important points. For this purpose, we further developed the peer-oriented attention guidance functionality proposed by Eryilmaz et al. [14] and offered students the option of both increasing and decreasing text font size. We defined two CSS classes with corresponding font sizes: big and bigger. The premise behind the bigger font size is to depict peer consensus on collaboratively decided important points. In order to be consistent with the font size, we set the bigger font size to be 150% larger than the big font size.

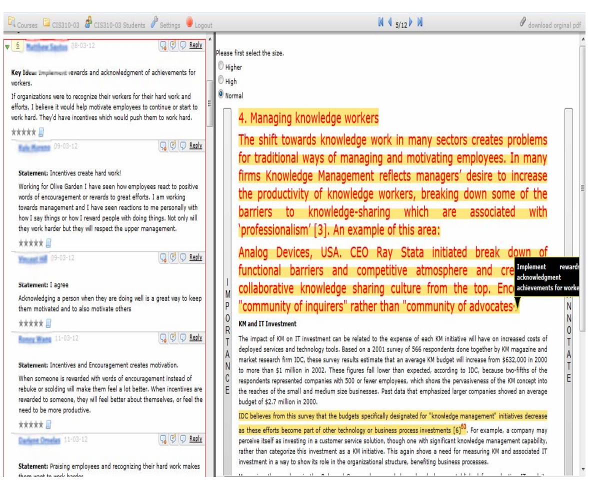

**Figure 2. Peer-oriented attention guidance functionality**

## 3.3. Control software system

The third version (Figure 3) is a regular system for anchored discussion that is enhanced with Marginalia Javascript program. This system serves as the control condition to evaluate the effectiveness of aforementioned attention guidance functionalities because it does not support attention guidance functionality. We will next describe the research questions derived from these software designs.

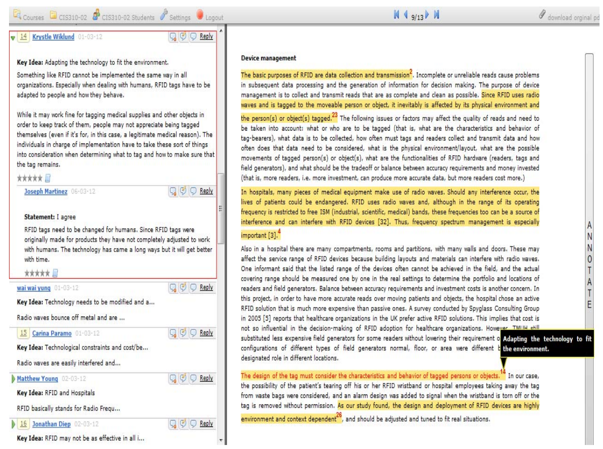

**Figure 3. Control software system**

# 4. Research Questions

Given the limited body of empirical research on attention guidance in CSCL systems [15], this study aims at examining the unique value of two different modes of scaffolds, faded instructor-based and peer-oriented attention guidance, to advance collaborative knowledge construction in discussion threads that focus on important information from complex instructional materials. More specifically, we ask the following research questions:

1. What is the impact of two different modes of scaffolds on students' attention allocations in online learning conversations?
2. How do students' interaction patterns in online learning conversations differ among software designs?
3. Do students' interaction patterns in online learning conversations vary across time?

# 5. Method

We conducted an experimental study with 150 junior level business major students distributed in three sections of a blended-format management information systems course. Each section had 50 students. Student profiles in terms of the ratio of male to female students, representation of diverse ethnicities, average years of college study completed, and competency in using the computer were similar the three sections. The same instructor taught all three sections of the course. The learning objective of this course was to show students how information helps organizations to accomplish organizational goals and provides strategic advantage for business. In order to answer the research questions, we randomly assigned each section to a software design: faded-instructor based attention guidance functionality, peer-oriented attention guidance functionality, and control software system. Within each section, students received a brief training in the respective functionality of the utilized software before the experiment began. All three sections covered the same learning material in an identical way during the class sessions. The learning material encompassed four articles sequenced in the following order: "Strategy and business models what is the difference"; "Identifying user behavior in online social networks"; "RFID applications in hospitals a case study on a demonstration RFID project in a Taiwan hospital", and "Knowledge management metrics via a balanced scorecard methodology." Each article was covered during a two-week online discussion period. Based on an ongoing diagnosis of students' attention allocations, the instructor gradually removed cues in the faded instructor-based attention guidance functionality. For the other groups, except for providing the topics for discussion, the instructor was not involved in any way unless students asked for help. Participation in the online discussion was compulsory and represented 30% of the overall grade. The minimum participation requirement was to post two messages per article and respond to at least two fellow students' messages for that article. When using the peer-oriented attention guidance functionality, every student was additionally asked to use the importance bar at least once per discussion in order to stimulate collaborative decision-making on important points from text. The data set stemmed from the experimental study included the transcripts of 12 online discussions. We describe below the qualitative and quantitative methods of analyses used to answer the research questions.

## 5.1. Analysis of students' attention allocations

We constructed qualitative heat maps based on students' cursor movements to provide comprehensive pictures of their attention allocations during the experiment (see Chen et al. [30] for a strong positive correlation between cursor movement and attention allocation). The heat maps utilized ClickTale Web service. We ran each discussion topic's tracking for two weeks. The standardized colors on the heat maps ranged from red to blue, allowing us to compare students' attention allocations. Red color suggests areas that received the most student attention; the yellow color suggests areas that received less student attention; and blue color suggests areas that received the least student attention during online discussions.

## 5.2. Analysis of students' interaction patterns

This study employed quantitative content analysis and sequential analysis to examine students' interaction patterns. We adopted the interaction analysis model developed by Gunawardena et al. [31] to code and count messages for variables of interest. The unit of content analysis was each complete message in the online discussion because students' messages were rather short and mainly consisted of one type of knowledge construction activity (see Eryilmaz et al. [6] for the suitability of this analysis unit in similar studies). The coding items of Gunawardena et al.'s [31] model enabled us to examine five phases of knowledge construction. The first phase, sharing information, involved statements of initial individual interpretations. The second phase, exploring dissonance, represented identification of areas of disagreement among interpretations. The third phase, negotiating meaning, underscored exchange of arguments to resolve disagreements. The fourth phase, testing proposed synthesis, entailed the evaluation of a proposed synthesis against received facts. Finally, the fifth phase, agreeing on new knowledge, demonstrated summarization of agreement(s) as a result of the online discussion.

The above mentioned quantitative content analysis served as a baseline to model two-event sequences between different knowledge construction phases in threaded discussions (an analysis tracing longer sequences is currently under way, and will be reported in future publications). A central underlying premise of this analytic framework is that messages in threaded discussions are inherently interconnected and dynamically affect one another. Based on this premise, we employed the Discussion Analysis Tool (DAT) developed by Jeong and Frazier [33] to carry out sequence analysis. DAT modeled two-event sequences by computing mean response scores that indicate how many times a given type of message is able to produce a specific type of response category.

## 6. Results

The presentation of the results follows the order of our research questions. First, we present the impact of two different modes of scaffolds on students' attention allocations in online learning conversations. Second, we show how interaction patterns in online learning conversations differ among software designs. Third, we highlight group differences in interaction patterns across time.

### 6.1. Results of students' attention allocations

With respect to the first research question, the heat maps provided comprehensive pictures of students' attention allocations in online learning conversations. Figure 4 portrays a heat map derived from 32 page views by 32 students assigned to the faded instructor-based attention guidance functionality. This heat map reveals that students devoted most attention to instructor determined important perspectives from text and sticky messages summarizing students' key ideas for annotating those perspectives (e.g., "I do not see why this matters" which lead to further discussions), as suggested by the red color.

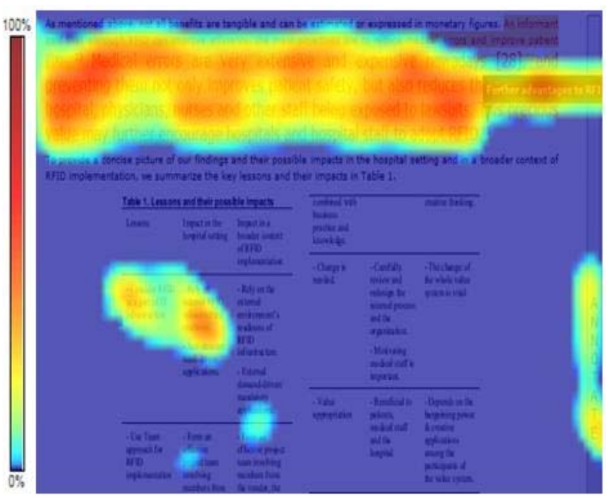


**Figure 4. Heat map for faded instructor-based attention guidance functionality**

Figure 5 shows a heat map derived from 34 page views by 34 students assigned to the peer-oriented attention guidance functionality. In line with Figure 4, the heat map for peer-oriented attention guidance functionality exposes a concentrated attention around a sticky message on bigger font size text suggesting that the key idea posted by a student for annotating this passage reflects a shared misconception by other students who invest a collaborative effort into developing a better understanding of the passage, as suggested by the red color.

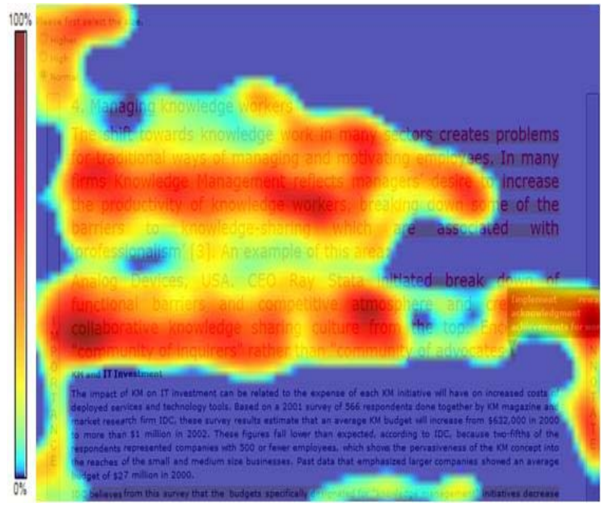


**Figure 5. Heat map for peer-oriented attention guidance functionality**

Conversely, Figure 6 presents a disheartening heat map derived from 27 page views by 27 students assigned to the control software system. Strikingly, this heat map depicts that students' attention was more distributed with respect to annotations on text, but less concentrated in any particular annotation, as evidenced by the yellow and green colors. Additionally, this heat map demonstrates that sticky messages summarizing students' key ideas for making those annotations received less attention from group members when the entire text had the default font size.

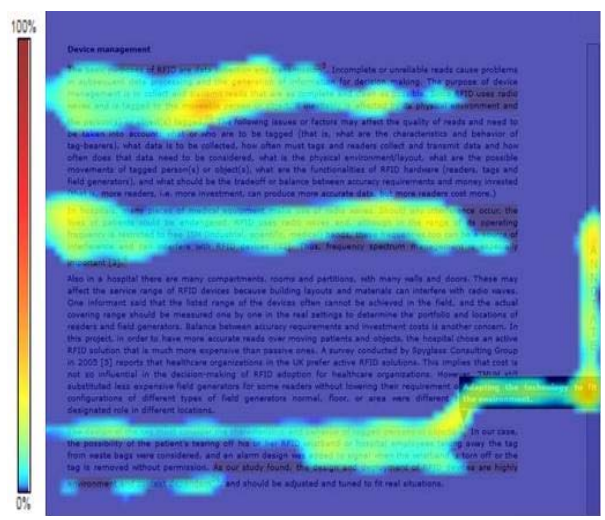


**Figure 6. Heat map for control software system**

Taken together, the qualitative analysis of the heat maps suggests that two different modes of scaffolds focused students' attention to important information from complex instructional materials in online learning conversations.

### 6.2. Results of students' interaction patterns

With respect to the second research question, the results incorporate two parts: quantitative content analysis for sorting individual messages into knowledge construction phases adopted from Gunawardena et al.'s [32] model and sequential analysis for modeling two-event sequences between different knowledge construction phases in threaded discussions. 12 online discussions yielded a total of 2315 task-related messages for all the discussion groups. Three independent coders who were blind to the study's purpose were trained to use Gunawardena et al.'s [32] model with a random sample of 100 messages. After training, each coder independently coded all messages in the data set. The coding took 80-100 hours per coder, who received financial compensation in return. The inter-rater Krippendorff's alpha reliability was 0.74, which exceeds 0.67 and indicates a satisfactory agreement beyond chance. All disagreements between coders were resolved by discussion. To assess group differences in the proportions of knowledge construction phases, chi-square analyses were conducted. Omnibus chi-square analyses uncovered statistically significant group differences in the proportions of sharing information, exploring dissonance, and negotiating meaning messages (see Table 1). The control group posted a significantly greater proportion of sharing information messages than the groups assigned to peer-oriented and faded instructor-based attention guidance functionalities, $\chi^2 = 31.46$, $p < .001$; $\chi^2 = 51.86$, $p < .001$, respectively. Furthermore, the control group posted a significantly smaller proportion of exploring dissonance messages than the groups assigned to peer-oriented and faded instructor-based attention guidance functionalities, $\chi^2 = 14.39$, $p < .001$; $\chi^2 = 25.49$, $p < .001$, respectively. Finally, the control group posted a significantly smaller proportion of negotiating meaning messages than the groups assigned to peer-oriented and faded instructor-based attention guidance functionalities, $\chi^2 = 24.31$, $p < .001$; $\chi^2 = 22.30$, $p < .001$, respectively. There were no significant differences between the groups assigned to peer-oriented and faded instructor-based attention guidance functionalities in the proportions of knowledge construction phases, all *p*s > .12.

To assess group differences in mean response scores for two-event sequences between different knowledge construction phases in threaded discussions, all 2315 task-related messages were ordered chronologically and a series of ANOVAs were conducted.

**Table 1. Content analysis results**

| | Control Group | | Peer-Oriented Attention Guidance Functionality Group | | Faded Instructor-Based Attention Guidance Functionality Group | | Test of Significance | |
|---|---|---|---|---|---|---|---|---|
| | % | *f* | % | *f* | % | *f* | $\chi^2$ | *p* |
| Sharing Information | 52 | 370 | 38 | 294 | 34 | 278 | 57.13 | <.001* |
| Exploring Dissonance | 18 | 129 | 26 | 206 | 29 | 240 | 26.38 | <.001* |
| Negotiating Meaning | 19 | 136 | 30 | 236 | 30 | 243 | 29.80 | <.001* |
| Testing Proposed Synthesis | 7 | 51 | 4 | 34 | 5 | 41 | 6.29 | 0.043 n.s. |
| Agreeing on New Knowledge | 4 | 25 | 2 | 12 | 2 | 20 | 4.54 | 0.103 n.s. |
| Total | 100 | 711 | 100 | 782 | 100 | 822 | | |

*Note.* * indicates a statistically significant finding. All *p* values compared to Bonferroni adjusted $\alpha = .0025$ to account for familywise error. All chi-squares tested with df = 2, N = 2315.

There were statistically significant group differences in the mean response scores for the following two-event sequences: sharing information to exploring dissonance, exploring dissonance to negotiating meaning, exploring dissonance to sharing information, and negotiating meaning to negotiating meaning (see Table 2). Follow up simple effects testing uncovered the control group had significantly fewer two-event sequences concerning sharing information to exploring dissonance, and exploring dissonance to negotiating meaning than the groups assigned to peer-oriented and faded instructor-based attention guidance functionalities (all *p*s < .002, all *d*s > .35). Moreover, the control group had a significantly greater amount of exploring dissonance to sharing information sequence than the groups assigned to peer-oriented and faded instructor-based attention guidance functionalities (all *p*s <.001, all *d*s > .49). Finally, the control group had significantly fewer negotiating meaning to negotiating meaning sequence than the group assigned to peer-oriented attention guidance functionality, $t(460) = 3.52$, $p < .001$, $d = .33$. Concerning group differences in two event sequences for the peer-oriented and faded instructor-based attention functionalities, the group assigned to peer-oriented attention guidance functionality had a greater amount of negotiating meaning to negotiating meaning sequence than the faded instructor-based attention guidance functionality group, $t(614) = 5.46$, $p < .001$, $d = .36$).

With respect to the third research question, one significant finding was uncovered. While there were no statistically significant differences in negotiating meaning to negotiating meaning sequences during the first discussion and second discussion, the peer-oriented attention guidance functionality group had significantly more negotiating meaning to negotiating meaning sequence than the control and faded-instructor based attention guidance functionality groups during the last discussion, $t(133) = 1.99$, $p = .049$, $d = .46$; $t(169) = 2.057$, $p = .04$, $d = .33$, respectively. Furthermore, there was a trend for significance at discussion three, where the peer-oriented attention guidance functionality group had a greater mean frequency of negotiating meaning to negotiating meaning sequence than the control and faded instructor-based attention guidance functionality groups, $t(127) = 1.98$, $p = .05$, $d = .46$; $t(170) = 1.94$, $p = .054$, $d = .34$, respectively (See Figure 7 for a visual depiction).

**Table 2. Sequence analysis results**

| Two-Event Sequences | Control Group | | Peer-Oriented Attention Guidance Functionality Group | | Faded Instructor-Based Attention Guidance Functionality Group | | ANOVA | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *M* (SD) | *N* | *M* (SD) | *N* | *M* (SD) | *N* | *df* | *F* | $\eta^2$ | *p* |
| Sharing Information → Exploring Dissonance | 0.19 (0.47) | 352 | 0.40 (0.7) | 284 | 0.43 (0.74) | 320 | 2, 2943 | 13.99 | 0.03 | <.001 |
| Exploring Dissonance → Negotiating Meaning | 0.96 (0.96) | 125 | 1.35 (1.13) | 167 | 1.61(1.42) | 158 | 2, 2447 | 10.28 | 0.04 | <.001 |
| Exploring Dissonance → Sharing Information | 0.94 (1.08) | 125 | 0.46 (0.88) | 167 | 0.42 (0.8) | 158 | 2, 2447 | 13.55 | 0.06 | <.001 |
| Negotiating Meaning→ Negotiating Meaning | 0.05 (0.22) | 136 | 0.26 (0.68) | 326 | 0.01(0.39) | 290 | 2, 2749 | 19.41 | 0.05 | <.001 |

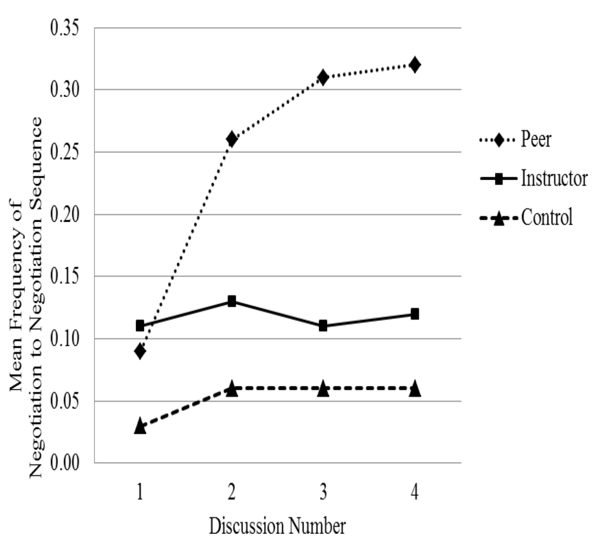


**Figure 7. Mean frequency of negotiating meaning to negotiating meaning sequences as a function of group and time**

## 7. Conclusion

The study reported in this paper is part of an action design cycle focusing on the design and evaluation of CSCL systems for preparing students to manage inter-professional expertise and collaborative construction of new knowledge in today's complex information systems projects. Accordingly, we addressed three original research questions.

In response to the first research question, comprehensive pictures from heat maps exposed that both types of scaffolds effectively focused students' attention to important information from complex instructional materials, which is one of the essential processes for active learning [17, 18]. This important finding is in line with tag cloud research that demonstrates the strong effect of font size to capture attention in an involuntary or obligatory fashion [30]. To our knowledge, the heat maps presented in this paper provide initial insights that open the black box of students' attention allocations on instructional materials in online discussions.

In response to the second research question, both types of scaffolds increased the proportions of exploring dissonance and negotiating meaning message categories. However, in line with Schellens and Valckle [34], we found very few activities in the higher categories. Moreover, both types of scaffolds improved the mean response scores for the following two-event sequences: sharing information to exploring dissonance, exploring dissonance to negotiating meaning, and negotiating meaning to negotiating meaning. These empirical findings indicate that the proposed attention guidance functionalities offer students an indirect way of focusing their attention on deep processing of challenging concepts in an inherently open learning environment.

In response to the third research question, we found a positive upward trend of negotiating meaning to negotiating meaning sequence for the peer-oriented attention guidance functionality group. This trend underscores students' preference for discussions in their own language with their own group as they become aware of peers' knowledge gaps (see Caldwell [28] for a similar argument).

We thus conclude that faded instructor-based and peer-oriented attention guidance functionalities can support students to use complex instructional materials more constructively in online learning conversations. Our next steps will comprise investigating alternatives methods of collecting data on attention without imposing restrictions on students and clarifying the relationship between scaffolding techniques and student learning outcomes.

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