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Abstract:

This paper reports a theory-driven experimental study for designing and evaluating two different forms of attention-guidance functionalities integrated into an anchored-discussion system. Using social constructivism as a motivating theory, we constructed a theoretical framework that emphasizes the importance of students' attention allocation in online learning conversations and its influence on message quality and interaction patterns. The development of the functionalities, named faded instructor-led and peer-oriented attention guidance, aimed to direct students' attention toward instructional materials' central domain principles while offering them an open learning environment in which they could choose their own topics and express their own ideas. We evaluated the functionalities with heat map analysis, repeated measures general linear model analysis, and sequence analysis to assess the utility of the developed functionalities. Results show that attention guidance helped students more properly allocate their attention in online learning conversations. Furthermore, we found that the improved attention allocation led to better quality of students' online learning conversations. We discuss implications for researchers and practitioners who wish to promote more fruitful online discussions.

Keywords: Design Science, Computer Supported Collaborative Learning, Attention Guidance, Social Constructivism, Heat Maps. Repeated Measures General Linear Model Analysis

1 Introduction

A unique characteristic of real-world information systems (IS) development projects is the intense collaboration among IS staff, project leaders, end users, and management. Through collaboration, team members set achievable goals, resolve misunderstandings about design decisions, and negotiate deliverables for each stage of a phased-lifecycle approach (Balijepally, Mahapatra, Nerur, & Price, 2009). Toward this end, it is essential for IS students to understand how one can pursue initial ideas over time via fruitful discussions to progressively form more coherent ideas for addressing real-world problems. This collaboration skill becomes particularly important to cultivate as employers increasingly ask employees to work in virtual teams (Majchrzak, Malhotra, & John, 2005). Collaborative learning encompasses a broad spectrum of didactical approaches that enable IS educators to help students express persuasive arguments, interpret viewpoints, and negotiate meanings. As Stahl (2013) point out, 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 done in the real world.

Computer-supported collaborative learning (CSCL) systems offer the potential for students to practice continuous improvement of ideas with the availability and salience of their affordances (Suthers, 2006). The open source anchored discussion system developed by van der Pol, Admiraal, and Simons (2006) is an effective tool that supports and increases the quality of collaboration in online discussions. This CSCL system's design is based on an annotation functionality that Suthers (2001) identified to tightly couple learning material with asynchronous discussion. van der Pol et al. (2006) demonstrated that the system at hand affords a more efficient and meaning-oriented collaboration than a normal threaded discussion. Next, Eryilmaz, Ryan, van der Pol, Kasemvilas, and Mary (2013a) compared two versions of this system and reported that online presence of learning material supports content-focused discussions. Moreover, providing annotation functionality promotes complex patterns of collaborative knowledge-construction activities and re-focuses the discussion when conversations digress. Finally, Eryilmaz, van der Pol, Ryan, Clark, and Mary (2013b) showed that the relevant annotation functionality reduces explicit coordination activities during collaborative processing of academic literature and, thereby, avails students more time and effort for demanding knowledge-construction activities that positively associate with individual learning outcomes (see Mary (2014) for similar learning findings).

However, despite the potential for learning, evidence for it has been limited in part because discussions threads that focus on central concepts, principles, and their interrelations from instructional materials have a tendency to die, which leaves little opportunity for diagnosing and resolving misconceptions (Hewitt, 2005). This pressing problem stresses that students may not deeply process important information from instructional materials in online discussions, which inhibits learning. Along this line, Hewitt (2005) demonstrated that students gravitate towards familiar topics and avoid challenging ones to meet online discussion requirements. According to Jeong and Hmelo-Silver (2010), students' above-mentioned tendencies induce shallow processing instead of deep processing of instructional materials. Under such circumstances, Kim and Hannafin (2011) remark that "students develop robust and oversimplified misconceptions that prove highly resilient to change" (p.412). The factors that give rise to this problem are twofold. First, students can be overwhelmed when everything looks important in text (Scheiter & Gerjets, 2007). Second, students tend not to effectively use help facilities offered by online learning environments when they associate seeking help as a threat to self-esteem or autonomy (Karabenick, 2011). Taken together, both factors indicate that merely providing instructional materials in anchored discussion systems is not enough for students to develop a deep understanding of a text. Thus, the question arises, how can we unobtrusively focus students' attention on the processing of central concepts, principles, and their interrelations from instructional materials in online discussions?

To answer this subtle and complex question, we followed a design science research methodology (Hevner, March, Park, & Ram, 2004) to develop and evaluate two different forms of attention-guidance functionalities, which we integrated into an updated open source anchored-discussion system. We developed the functionalities, named faded instructor-led and peer-oriented attention guidance, based on a social constructivist perspective to facilitate focused processing of instructional materials' central domain principles in online discussions. We evaluated the functionalities based on an experiment that employed quantitative and qualitative techniques to compare two modes of attention-guidance functionalities with each other and with a regular anchored-discussion system (as the control condition).

This paper proceeds as follows. In Section 2, we propose a theoretical framework that informed our developing the instructor-led and peer-oriented attention-guidance functionalities. In Section 3, we explain

how we developed two attention-guidance functionalities integrated into an updated open source anchored-discussion system. In Section 4, we present two original research questions to evaluate the utility of the developed attention-guidance functionalities. In Section 5, we outline the experimental setup, methods, and operationalization. In Section 6, we report our findings. In Sections 7 and 8, we discuss our findings and the study's limitations. Finally, in Section 9, we conclude the paper.

2 Theoretical Framework

Social constructivism, the motivating theory in our study, considers that deep learning can be best achieved in an active and meaningful way. As such, collaborative knowledge-building discourse or “learning conversations” (as van der Pol (2009) note), which requires sustained creative work to generate and improve ideas, is an excellent way to realize deep learning (Cress & Kimmerle, 2008). From a social constructivist perspective, we can view students' ideas as knowledge objects (Lipponen, Hakkarainen, & Paavola, 2004) that can be improved continually through collaboration. A crucial aspect of this collaborative “knowledge building” (also known as discovery learning, knowledge construction, or inquiry learning) is that it promotes the collective development of knowledge that no single individual could have constructed alone. That way, collaborative knowledge building has the potential to not only deepen students' individual learning processes by making it more active and meaningful but also to enrich their understanding of a topic beyond what they could have reached on their own (Stahl, 2006). However, as Dillenbourg (1999) points out, collaborative learning's potential is not always easy to realize because collaboration through open discourse also creates room for “noise” and distraction (requiring one to manage the interaction itself), and there is no guarantee that group discourse will focus on instructional materials' central concepts, principles, and their interrelations (see Hewitt, 2005; Jeong & Hmelo-Silver, 2010; Kim & Hannafin, 2011, for similar arguments). Based on this concern, CSCL research on constructivist learning has shown that students with low domain knowledge need attention guidance, which helps them to separate pertinent from non-pertinent and important from non-important information (e.g., Kirschner, Sweller, & Clark, 2006; Hmelo-Silver, Duncan, & Chinn, 2007).

The idea that students need help to properly allocate their attention is not new. Early research on individual reading comprehension has already identified “attention” as an important resource in the reading process and has defined it as the allocation of cognitive processing resources toward making sense of instructional materials' central domain principles (Anderson, Reynolds, Schallert, & Goetz, 1977; Kintsch & van Dijk, 1978). Several studies on reading comprehension have also found that guiding students' attention can prompt them to mindfully interact with or reflect on a text's relevant information. For example, Lorch and Lorch (1995) show that attention guidance slowed down students' reading times for relevant portions of a text. Cognitive theories on individual learning have underscored this importance of selecting relevant information for comprehension and learning. As Mayer (1999) shows, students can comprehend central domain principles from a complex academic text through a cognitive process of selecting relevant information, organizing selected information into a coherent representation, and integrating a coherent representation of the information with existing knowledge.

The first step in the cognitive process that Mayer (1999) defines, selecting relevant information, is especially crucial in students' collaborative-learning cycle because it supports their subsequent collaborative knowledge-construction activities by focusing students' shared attention toward relevant information in a text. As Gunawardena, Lowe, and Anderson (1997) show, for students to successfully construct meaning collaboratively, they need to undertake knowledge-construction activities in a certain order. This collaborative learning model comprises an iterative cycle of the following activities: sharing information, exploring dissonances, negotiating meanings, testing proposed syntheses, and agreeing on new knowledge. In his collaborative knowledge building model, Stahl (2000) points out that the individual cognitive processes that Mayer (1999) defines form a prerequisite for the initial steps in this collaborative-knowledge cycle, the sharing of information, or tacit pre-understandings. As such, we identify proper attention allocation as an important input and prerequisite for successful collaborative learning. Finally, we place students' online discussion message quality and interaction patterns at the heart of our study because these two variables illuminate the kinds of collaborative activities students engage in that may influence their learning (Zhao & Chan, 2014), and, thus, CSCL's success (van Drie, van Boxtel, Jaspers, & Kanselaar, 2004). Now, we will turn our attention towards the question of how to support proper attention allocation in students' online learning conversations.

2.1 Guiding Attention Allocation

To the best of our knowledge, researchers have not previously implemented or studied attention guidance in CSCL in the context of students' online literature processing. Researchers have, however, studied attention guidance in the context of multimedia learning. Dodd and Antonenko (2012) define attention guidance in multimedia learning as "the placement of non-content visual and or verbal elements that serve to guide the learner's attention and aid in the cognitive processes of selecting and organizing instructional materials" (p. 1103). An important implication from existing attention guidance research is that attention guidance can help to focus students' attention on relevant information (de Koning, Tabbers, Rikers, & Paas, 2009). There is, however, a discrepancy in the literature concerning the effects of attention guidance on deep processing of relevant information. On the one hand, Boucheix and Lowe (2010) show that attention guidance supported the construction of a mental model of causal chains in cued areas. Similarly, De Koning, Tabbers, Rikers, and Paas (2007) found that attention guidance improved retention and transfer performance. On the other hand, Kriz and Hegarty (2007) failed to find better learning outcomes for cued compared to non-cued instructional resources. In other words, studies thus far show that attention guidance may help locate relevant information, but there is inconclusive evidence when it comes to the deep processing of relevant information.

When applied to online learning conversations, we can define attention guidance as using visual cues to help students collaboratively process instructional materials. After reviewing the social constructivist literature on possible forms of guidance in general, we identified two relevant forms of guidance that may effectively support students' collaborative-learning process. The first form is guidance that an instructor provides that is gradually faded out or "scaffolded" when students become more proficient. The second form is guidance that students themselves (peer-to-peer) provide, which makes them more active and responsible in the collaboration process. Applying these two general forms of guidance, we design two forms of attention guidance for collaborative literature processing to help students focus on the central domain principles from their instructional materials: 1) faded instructor-led attention guidance and (2) peer-oriented attention guidance.

2.1.1 Faded Instructor-led Attention Guidance

The first form of guidance, instructor-led guidance, describes the assistance that a trained individual (instructor) provides to help students focus their deliberate knowledge-construction activities on important information that they might otherwise overlook. Ideally, instructor support gradually diminishes over time so that students progressively become more independent and more able to identify relevant information on their own. In the educational sciences, this form of fading guidance is usually referred to as "scaffolding". Because it concerns the gradual transfer of an instructor's supporting activity to the students who have to appropriate it as their own, we can define scaffolding as an interactive process of diminishing instructor support that requires both instructors' and students' active participation (Puntambekar & Hubscher, 2005).

As van de Pol, Volman, and Beishuizen (2010) note, scaffolding has three key characteristics: contingency, fading, and transfer of responsibility. The first characteristic, contingency, is the calibration of an instructor's assistance to students' current level of competence. For our purposes, the most important aspect of this characteristic is to introduce an instructor's assistance without dominating or restricting the exploratory and creative potential of students' collaborative knowledge construction. For example, Race (2013) reports that students have a tendency to switch off mentally if an instructor's assistance provides them all the answers. In a similar vein, Zahn, Krauskopf, Hesse, and Pea (2012) state that students can feel overwhelmed or become bored by an instructor's extensive instructions before they really start doing anything.

One way for an instructor to provide contingent assistance is to increase the font size of central domain principles from instructional materials. As De Koning et al., (2009) state in their text-processing research, font size is an effective visual property to capture students' attention in an involuntary or obligatory fashion without altering the meaning or content of instructional materials. In this respect, the purpose of an instructor's contingent assistance is to help students to identify what they need to understand from instructional materials (Kim & Hannafin, 2011). Given that attention provides the foundation for constructing knowledge in online discussions (Schneider & Pea, 2013; Stahl, 2013), this form of guidance can implicitly invite students to identify and negotiate diverse perspectives focusing on central domain principles from instructional materials.

The second characteristic, fading, is the gradual withdrawal of an instructor's assistance as determined by the outcomes of a continuous diagnosis and calibration cycle. Fading of an instructor's assistance is strongly

related to the third characteristic, transfer of responsibility. In the scaffolding paradigm, a cognitive line of argument for the necessity of fading is that, without it, students do not internalize and appropriate the desired competencies. In other words, fading forces skill acquisition (Wecker & Fischer, 2007). Although researchers consider the fading of an instructor's guidance to be important in online discussions, research results of its effects are sparse and inconclusive. On the one hand, McNeill, Lizotte, Krajcik, and Marx (2006) demonstrate that, when instructor guidance faded in online discussions, students continued to identify and negotiate diverse perspectives focusing on central domain principles from instructional materials (see Eryilmaz, Chiu, Thoms, Mary, & Kim, 2014; Hsieh & Tsai, 2012, for similar findings). On the other hand, Lazonder and Rouet (2008) found that students were unable to articulate strong explanations that focus on instructional materials' central domain principles when they passively interacted with the instructor's guidance (see Oliver & Hannafin, 2001, for similar findings). In the light of this disparity, we describe below a second form of guidance that relies more on students themselves.

2.1.2 Peer-oriented Attention Guidance

The second form of guidance that we will implement in this study refers to students that help each other with identifying the important parts of their instructional materials. In other words, it concerns collaborative guidance from untrained individuals (equal-status students). Thus, the term "peer-oriented attention guidance" that we use in this study underscores a group of students' collective responsibility to determine instructional materials' central domain principles on their own. This form of guidance aims to support two learning mechanisms as King (1998) notes: monitoring peers' explanations of what they think are the central domain principles and providing focused feedback on those explanations.

The first mechanism, monitoring peers' explanations, prompts students to locate instructional materials' central domain principles by using peers' explanations as a resource for learning. For example, students who have difficulty finding instructional materials' central domain principles can stay focused on task by monitoring peers' explanations (Caldwell, 2007). In this respect, monitoring is an active rather than passive activity that indicates students' openness to thoughtfully consider divergent explanations (Wise, Zhao, & Hausknecht, 2014). Through monitoring, students can identify conflicting evidences (Scardamalia, 2002), which spark and sustain the second mechanism we describe below.

The second mechanism, providing focused feedback, prompts students to reflect on instructional materials' central domain principles and assess the evidences behind both their own and peers' explanations. Reflection involves reading and re-reading instructional materials' central domain principles (van der Pol et al., 2006). Asynchronous online discussions offer a high affordance for reflection because they are not in real time and open up opportunities for students to refer to each other's explanations in meaningful ways. That is to say, as students read and re-read instructional materials' central domain principles in their own time, they can explore conflicting evidences, drop false points of view, or modify initial standpoints to eliminate misunderstandings. Therefore, researchers regard this second mechanism as being able to highly improve understanding and knowledge construction (Baker, 1999).

In summary, our two means of attention guidance aim to subtly direct students' attention in online learning conversations toward the central domain principles of their instructional materials, while, at the same time, offering them an open learning environment in which they can choose their own topics and express their own ideas. Based on this theoretical framework, in Section 3, we focus on developing faded instructor-led and peer-oriented attention-guidance functionalities integrated into an open source anchored-discussion system.

3 Artifact Development

Design science research (DSR) is an important paradigm of IS research that creates new knowledge through building and evaluating innovative artifacts (Hevner et al., 2004). The term artifact, as defined Gregor and Hevner (2013), is a "thing that has, or can be transformed into, a material existence as an artificially made object" (p. 341). Given our intent (i.e., unobtrusively focusing students' attention on processing central domain principles from instructional materials in online discussions), we followed the DSR guidelines that Hevner et al. (2004) describe to ensure that the artifacts produced are research contributions. Table 1 explains how we implemented Hevner et al.'s (2014) guidelines in our research.

Table 1. Design Science Research Methodology (Following Hevner et al., 2004)

| Guideline | Description (Hevner et al., 2004) | Application to this research |
|--------------------------------------|---|--|
| 1. Design as an artifact | “DSR must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.” | The information technology (IT) artifacts for this study are two attention-guidance functionalities integrated into van der Pol et al.’s (2006) open source anchored-discussion system. Artifact 1: faded instructor-led attention-guidance functionality. Artifact 2: peer-oriented attention-guidance functionality. |
| 2. Problem relevance | “The objective of DSR is to develop technology-based solutions to important and relevant business problems.” | The IT artifacts aim to address the following known problem in online learning conversations: <ul style="list-style-type: none"> • Online discussion threads that focus on central concepts, principles, and their interrelations from instructional materials have a tendency to die, which leaves little opportunity for diagnosing and resolving misconceptions (Hewitt, 2005). |
| 3. Design evaluation | “The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.” | <ul style="list-style-type: none"> • We conducted an experimental study to evaluate the IT artifacts. • We measured utility, quality, and efficacy through heat map analysis, repeated measures general linear model analysis, and sequence analysis. |
| 4. Research contributions | “Effective DSR must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.” | Contributions were made in the form of: <ul style="list-style-type: none"> • Applying social constructivist knowledge to the design of IT artifacts. • Evaluating IT artifacts to advance previous social constructivist knowledge. |
| 5. Research rigor | “DSR relies on applying rigorous methods in both constructing and evaluating design artifacts.” | Rigorous methods applied for the research include: <ul style="list-style-type: none"> • Designing IT artifacts following existing theoretical knowledge on social constructivism. • Evaluating the IT artifacts using validated instruments based on existing research. |
| 6. Design as a search process | “The search for an effective artifact requires using available means to reach desired ends while satisfying laws in the problem environment.” | The process for an effective IT artifact began with: <ul style="list-style-type: none"> • A search to discover unobtrusive ways to focus students’ attention on the processing of central domain principles from instructional materials in online discussions. • Understanding how font size as a visual property can capture students’ attention in an involuntary or obligatory fashion without altering the meaning or content of instructional materials. |
| 7. Communication of research | “DSR must be presented effectively both to technology-oriented and management-oriented audiences.” | We will share the research results in the form of several publications in academic conference proceedings and journals. |

Central to the premise of anchored discussion is the linking or “anchoring” of messages to the highlighted and numbered passages in a text to contextualize students’ ideas. We chose van der Pol et al.’s (2006) anchored-discussion system as the development platform for two reasons. First, the system has a user-friendly interface that provides a tight coupling of instructional material and its related discussion without hindering interaction among students (e.g., Eryilmaz, Van der Pol, Clark, Mary, & Ryan, 2010a; Eryilmaz, Van der Pol, Kasemvilas, Mary, & Olfman, 2010b; Eryilmaz, Alrushiedat, Kasemvilas, Mary, & van der Pol, 2009). Second, the system reduces explicit coordination activities in online discussions and, thereby, avails students more time and effort for demanding knowledge-construction activities that positively associate with individual learning outcomes (Eryilmaz et al. 2013b; Mary, 2014).

Before developing our attention-guidance functionalities, we updated the architecture of the system to represent each page of an instructional material in HTML format. This architectural update supported the installation of Marginalia, a browser-independent, open source JavaScript program, which facilitates fine-grained annotation of HTML pages (Xin, Glass, Feenberg, Bures, & Abrami, 2010). Marginalia allows users to create new annotations by selecting a desired passage with the mouse and then clicking on an annotation bar to the right of the instructional material. Two features of Marginalia are conducive to fostering a closer coupling between the instructional material and its related discussion. 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 (i.e., justification for making an annotation) in the direct context that elicited it by inserting a sticky message adjacent to an annotated passage. However, the flipside of this interface design, as Suthers (2001) notes, is that it may interfere with students’ reading as an instructional material becomes cluttered with sticky messages. To address this concern, we designed sticky messages to appear adjacent to annotations only under the mouse cursor. Thus, all versions of the proposed system promote contextual communication for deep processing of instructional materials. However, they differ from one another with respect to how attention is guided. To facilitate reusability and modularity, we developed each functionality as a separate piece of software (i.e., component) that can be integrated into a larger application, such as van der Pol et al.’s (2006) open source anchored-discussion system.

3.1 Faded Instructor-led Attention-guidance Functionality

The main objective of the faded instructor-led attention-guidance functionality is to help instructors scaffold students’ focused processing of central domain principles from instructional materials in online discussions. Figure 1 illustrates the user interface of the developed functionality. This interface runs only on the instructor account and it works when an instructor highlights a passage and clicks the importance bar on the left of the instructional material. The importance bar increases the font size of the highlighted passage. This visual contrast enables central concepts, principles, and their interrelations to become more noticeable and stand out against the rest of the text. The cascading style sheet associated with this functionality includes two font sizes: default and big. The default font size (10px) represents a medium level of importance. The big font size (15px) represents a high level of importance (see Eryilmaz, Ryan, Poplin, and Mary’s (2012) usability study for the identification of these font sizes).

The figure consists of two screenshots of an online learning platform interface. The top screenshot shows a discussion thread titled 'Further advantages to RFID.' The thread includes a 'Key Idea' section, a 'Statement' section, and a table titled 'Table 1. Lessons and their possible impacts'. The table has three columns: 'Lessons', 'Impact in the hospital setting', and 'combined with business practice and knowledge.' The bottom screenshot shows a discussion thread titled 'Clustering can be used to categorize many aspects of a wide variety.' The thread includes a 'Key Idea' section, a 'Statement' section, and a highlighted text block that reads: 'In summary, using the clustering methodology, we have identified up to 9 behaviors in which YouTube users can be categorized based on their individual and social attributes.' The interface also shows navigation buttons, a search bar, and a 'download original pdf' link.

Key Idea: Further advantages to RFID.

While the article discusses the many benefits RFID can have on a business's efficiency and it's cost benefits, organizations will realize further benefits as RFID technology becomes more widespread. From use in hospitals they realized the benefits of RFID in "reducing medical errors and improving patient safety." Different implementations such as this could prove very useful for a variety of different businesses.

★★★★★

Statement: organizations will realize further benefits as RFID technology becomes more widespread.

I agree, my friend worked for a company that would track other companies inventory using RFID technology. Since all inventory was scanned the company at any one time could look at the computer and know where they stand. very powerful for maximizing profits and tracking sales.

★★★★★

Statement: I agree with Scott.

This is shown the benefit of the development of IT in our life. There is no doubt how amazing of RFID affects all industries. Companies, which is using RFID for their business, may have competitive advantage. In hospital, RFID is able to help the hospital to run more efficiency and effectively. To help the hospital to reduce...

Table 1. Lessons and their possible impacts

| Lessons | Impact in the hospital setting | Impact in a broader context of RFID implementation | combined with business practice and knowledge. | creative thinking. |
|--|---|---|---|---|
| - Consider RFID as a part of IT infrastructure | - Rely on internal RFID infrastructure readiness. | - Rely on the external environment's readiness of RFID infrastructure. | - Change is needed. | - Carefully review and redesign the internal process and the organization. |
| - Self-directed need-driven applications. | - External demand-driven/mandatory applications. | - Form an effective project team involving members from the vendor, hospital's medical staff and IT unit and consultants. | - Value appropriation | - Motivating medical staff is important. |
| - Use Team approach for RFID implementation | - Form an effective project team involving members from the vendor, hospital's medical staff and IT unit and consultants. | - Negotiate & collaborate | - Beneficial to patients, medical staff and the hospital. | - The change of the whole value system is vital. |
| | | | | - Depends on the bargaining power & creative applications among the participants of the value system. |

Key Idea: Clustering can be used to categorize many aspects of a wide variety.

I never realized how useful clustering can be until this article. I never thought of the idea of clustering in regards to different types of groups that interact on YouTube. With clustering, I believe it helps to eliminate the confusion of relations among groups and efficiently separates them.

★★★★★

Statement: By identifying these different group of users of youtube they can also identify different user behaviors.

It is importance to identify the different user behaviors to potentially improve business in online social networks. Business managers will be able to better serve the the different groups of users in online social networking websites.

★★★★★

Statement: Agree with Paul, Clustering categorizes each composition group into unique and niche potential group that provides business with typical information to each unique condition.

When companies use clustering analysis strategy, they will see the whole picture of each component and each composition of them. there will be unique and focused trend telling companies to follow.it is just like the ABC classification in the marketing strategy. does it...

G4 - Producer & Consumer: This group corresponds to users that have both characteristics of producers and consumers. It represents the largest fraction of users (48%). They have moderately large number of subscribers and uploads, like the producers, and also browse many channels to watch and subscribe to videos, like the consumers. Clustering coefficient and reciprocity are low due to varying subscription targets and subscribers audience.⁴³

G5 - Other: A clear identification of this group is not possible because of the low values of every feature. However, possible interpretations, based on the short user age, are that it could correspond either to recent users or users that have abandoned their accounts. The low values of the features corroborate the recency hypothesis. However, when we analyze the absolute values we see that on average these users have subscribed to more videos than they have watched or the number of channels they have visited. One could consider this behavior as suspect in the sense that YouTube keeps a ranking of the most subscribed users. Accounts could have been created just to make a few isolated subscriptions and increase the rank of a few opportunist users that want to raise the popularity of their channels and videos.¹⁸

In summary, using the clustering methodology, we have identified up to 9 behaviors in which YouTube users can be categorized based on their individual and social attributes.^{24,34,32,1,12} So far, we have managed a total of nine different features, however do we need all these features to reach the same results? or, if we consider a smaller set of the most relevant features, what are the predominant behaviors? The next section answers these questions.

Figure 1. Screenshots of the Faded Instructor-led Attention-guidance Functionality (Instructor's View)¹

¹ Note: importance bar is not available to students in this operational software.

We consider the faded instructor-led attention-guidance functionality an innovative and purposeful IT artifact. It is innovative because existing anchored-discussion systems do not provide instructors with the dynamic capabilities to manipulate online documents' visual properties (for a review, see Wolfe, 2008). Moreover, it is purposeful for our goal because it supports three key characteristics of scaffolding. First, it supports contingency because students have the freedom to annotate text they deem important. If they annotate central domain principles with the big font size, then they still have to refine their own key ideas. Second, it supports fading because instructors can gradually decrease the number of central domain principles with the big font size from text. Third, it supports transferring responsibility because students have to distinguish central domain principles from text independently after the instructor fades their guidance.

3.2 Peer-oriented Attention-guidance Functionality

The impetus for the peer-oriented attention-guidance functionality is to facilitate collaborative guidance among students as they actively search for central domain principles from instructional materials. For this purpose, the peer-oriented attention-guidance functionality tailors the aforementioned importance bar towards students. Figure 2 displays the user interface of the developed functionality. This interface works by a student 1) highlighting a passage, 2) selecting a level of importance, and 3) clicking on the importance bar to the left of the instructional material. Depending on the selected level of importance, the importance bar either increases or decreases the font size of the highlighted passage. The cascading style sheet associated with this functionality includes three font sizes: default, big, and bigger. The premise behind the bigger font size is to depict peer consensus on collaboratively decided important points. For consistency, we set the bigger font size to be 150 percent larger than the big font size. Due to the limited real estate available in the margins of the learning material, we did not go above the bigger font size. However, we recorded the number of unique student remarks on a passage with the bigger font size in the database. Furthermore, we developed the peer-oriented attention-guidance functionality in a manner that prevented the same student from remarking a passage repeatedly and, thus, artificially inflating its importance. We took this approach to eliminate the risk of a single student biasing a group's consensus on collaboratively decided important areas.

We consider the developed peer-oriented attention-guidance functionality an innovative and purposeful artifact. It is innovative because it extends students' interactions with instructional materials beyond making annotations by letting students manipulate the font size of passages to indicate their perceived importance (see Wolfe, 2008 for characteristics of existing anchored discussion systems). In addition, it is purposeful for our goal because it supports the two learning mechanisms mentioned in the previous section. First, it supports monitoring peers' explanations of what they think are central domain principles from instructional materials because students can move the cursor over an annotated passage with the big or bigger font size to read such explanations. Second, it supports providing focused feedback on the appropriateness of the evidences behind peers' explanations because each feedback makes reference to an annotation (see Figure 3).

3.3 Control Software

To isolate the effects of the attention-guidance functionalities presented above, we developed a control version of the anchored discussion system that we enhanced with the Marginalia Javascript program but without any attention-guidance functionality. Figure 3 displays the user interface of the control software system.

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Matthew Santos 08-03-12 Reply

Key Idea: Implement rewards and acknowledgment of achievements for workers.
If organizations were to recognize their workers for their hard work and efforts, I believe it would help motivate employees to continue or start to work hard. They'd have incentives which would push them to work hard.

★★★★★

Wale Mwanza 09-03-12 Reply

Statement: Incentives create hard work!
Working for Olive Garden I have seen how employees react to positive words of encouragement or rewards to great efforts. I am working towards management and I have seen reactions to me personally with how I say things or how I reward people with doing things. Not only will they work harder but they will respect the upper management.

★★★★★

Yusef Hali 09-03-12 Reply

Statement: I agree
Acknowledging a person when they are doing well is a great way to keep them motivated and to also motivate others

★★★★★

Samuel Wale 11-03-12 Reply

Statement: Incentives and Encouragement creates motivation.

Please first select the size.
 Higher
 High
 Normal

4. Managing knowledge workers
The shift towards knowledge work in many sectors creates problems for traditional ways of managing and motivating employees. In many firms Knowledge Management reflects managers' desire to increase the productivity of knowledge workers, breaking down some of the barriers to knowledge-sharing which are associated with 'professionalism' [3]. An example of this area:
Analog Devices, USA. CEO Ray Stata initiated break down of functional barriers and competitive atmosphere and created a collaborative knowledge management culture from the top. Encourages "community of advocates".
Implement rewards and acknowledgment achievements for workers.

KM and IT Investment
The impact of KM on IT investment can be related to the expense of each KM initiative will have on increased costs of deployed services and technology tools. Based on a 2001 survey of 566 respondents done together by KM magazine and market research firm IDC, these survey results estimate that an average KM budget will increase from \$632,000 in 2000 to more than \$1 million in 2002. These figures fall lower than expected, according to IDC, because two-fifths of the respondents represented companies with 500 or fewer employees, which shows the pervasiveness of the KM concept into the reaches of the small and medium size businesses. Past data that emphasized larger

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4 Reptina Roberts 07-03-12 Reply

Key Idea: The four capitals which make up a knowledge-centric organization (KCO) are
Human capital is inside of us all and varies between us. An example of intellectual capital would be a trademark. Structural capital would include the building we go to school in or the computer I am writing this on. An example of virtual capital would be a forum or club for working professionals or maybe a fishing club.

★★★★★

Matthew Santos 08-03-12 Reply

Statement: I believe human capital might be the most important type of capital.
Although some people don't try as hard as other, I believe human capital is the most important type of capital because we all have the potential to be great or do something great. It's whether or not we're willing to put in the time and effort to produce such greatness. This could be where organizations implement rewards and incentives to push their employees to work hard and bring out their potential.

★★★★★

Subhilla Perera 11-03-12 Reply

Statement: I agree with this.
I agree that human capital is the most important type of capital an organization could have. It does not matter if you have a lot of other sources of capital if you do not have

Please first select the size.
 Higher
 High
 Normal

Use of Perspectives in KM
Perhaps the key to proper initiatives and drivers is selecting the right perspectives, to use the Kaplan and Norton phrase, to view the interaction between KM and the organizational strategy. This paper suggests that there might be two unique approaches to perspectives that would enhance the measurement of KM in the organization.³⁸
First Approach. The first approach would be to use the different types of capital available in an organization, as shown in Figure 2, to be the four different scorecard perspectives of how KM is leveraged in the organization.¹³ This approach is already in use in areas such as the U.S. government, who is empowered to these KM initiatives by the Clinger Cohen Act of 1996 (Public Law 104-106), formerly known as the IT Management Reform Act. This Act requires CIOs in government to focus on the core competencies which represent skills and knowledge needed for effective mission support using information technologies. The four capitals which make up a knowledge-centric organization (KCO) are [20]:

- Human capital is all individual capabilities, the knowledge, skill and experience of the employees and managers.
- Intellectual capital includes the intangibles such as information, knowledge and skills that can be leveraged by an organization to produce an asset of equal or greater importance than land, labor and capital.
- Structural capital includes the processes, systems that a firm owns less its people.
- Social capital is the goodwill resulting from physical and virtual interchanges between people with

The four capitals which make up a knowledge-centric organization (KCO) are

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Figure 2. Screenshots of the Peer-oriented Attention-guidance Functionality (Students' View)

The figure displays two screenshots of a control software interface, likely a discussion forum, showing threads and their associated content. The interface includes navigation elements like 'Courses', 'CIS310-02', 'CIS310-02 Students', 'Settings', and 'Logout' at the top. The threads are numbered 14 and 13.

Thread 14 (Top Screenshot):

- Post 14 (01-03-12):**
 - Key Idea:** Adapting the technology to fit the environment. Something like RFID cannot be implemented the same way in all organizations. Especially when dealing with humans, RFID tags have to be adapted to people and how they behave.
 - Text:** While it may work fine for tagging medical supplies and other objects in order to keep track of them, people may not appreciate being tagged themselves (even if it's for, in this case, a legitimate medical reason). The individuals in charge of implementation have to take these sort of things into consideration when determining what to tag and how to make sure that the tag remains.
 - Rating:** ★★★★★
 - Reply:** Joseph Murray (06-03-12)
 - Statement:** I agree. RFID tags need to be changed for humans. Since RFID tags were originally made for products they have not completely adjusted to work with humans. The technology has come a long ways but it will get better with time.
 - Rating:** ★★★★★
- Post 15 (01-03-12):**
 - Key Idea:** Technology needs to be modified and a...
 - Text:** Radio waves bounce off metal and are ...
 - Key Idea:** Technological constraints and cost/be...
 - Text:** Radio waves are easily interfered and...

Thread 13 (Bottom Screenshot):

- Post 13 (11-03-12):**
 - Key Idea:** By creating a Balance Scorecard a company can gain understanding. With a strategy of all a companies processes employees ca begin to break everything down to the point of understanding all of the companies processes.
 - Rating:** ★★★★★
 - Reply:** Joseph Murray (12-03-12)
 - Statement:** Agree. A balanced scorecard can provide organization, clarity, consistency, and accurate information all throughout the organization.
 - Rating:** ★★★★★
 - Reply:** Justin Thomas (13-03-12)
 - Statement:** The balance scorecard needs improvement. It is true that the balance scorecard needs to be more broken down. Also, it doesn't guide the companies into how to improve their weak points.
 - Rating:** ★★★★★
- Post 14 (11-03-12):**
 - Key Idea:** Developing Firms. When new firms are developed, a major...
 - Reply:** Justin Thomas (12-03-12)
 - Key Idea:** KM metrics and Balanced Scorecard. The aim of this article was to find a...

Main Content Area (Right Side):

- Text 1:** reads cause problems in subsequent data processing and the generation of information for decision making. The purpose of device management is to collect and transmit reads that are as complete and clean as possible. Since RFID uses radio waves and is tagged to the moveable person or object, it inevitably is affected by its physical environment and the person(s) or object(s) tagged.²³ The following issues or factors may affect the quality of reads and need to be taken into account: what or who are to be tagged (that is, what are the characteristics and behavior of tag-bearers), what data is to be collected, how often must tags and readers collect and transmit data and how often does that data need to be considered, what is the physical environment/layout, what are the possible movements of tagged person(s) or object(s), what are the functionalities of RFID hardware (readers, tags and field generators), and what should be the tradeoff or balance between accuracy requirements and money invested (that is, more readers, i.e. more investment, can produce more accurate data, but more readers cost more.)
- Text 2:** In hospitals, many pieces of medical equipment make use of radio waves. Should any interference occur, the lives of patients could be endangered. RFID uses radio waves and, although in the range of its operating frequency is restricted to free ISM (industrial, scientific, medical) bands, these frequencies too can be a source of interference and can interfere with RFID devices [32]. Thus, frequency spectrum management is especially important [3].⁴
- Text 3:** Also in a hospital there are many compartments, rooms and partitions, with many walls and doors. These may affect the service range of RFID devices because building layouts and materials can interfere with radio waves. One informant said that the listed range of the devices often cannot be achieved in the field, and the actual covering range should be measured one by one in the real settings to determine the portfolio and locations of readers and field generators. Balance between accuracy requirements and investment costs is another concern. In this project, in order to have more accurate reads over moving patients and objects, the hospital chose an active RFID solution that is much more expensive than passive ones. A survey conducted by Spyglass Consulting Group in 2005 [5] reports that healthcare organizations in the UK prefer active RFID solutions. This implies that cost is not so influential in the decision-making of RFID adoption for healthcare organizations. However, TMUH still substituted less expensive field generators for some readers without lowering their requirement of accuracy. Adapting the technology to fit the environment.
- Text 4:** The design of the tag must consider the characteristics and behavior of tagged persons or objects.¹⁴ In our case, the possibility of the patient's tearing off his or her RFID wristband or hospital employees taking away the tag from waste bags were considered, and an alarm design was added to signal when the wristband is torn off or the tag is removed without permission. As our study found, the design and deployment of RFID devices are highly environment and context dependent²⁶, and should be adjusted and tuned to fit real situations.
- Text 5:** For all the interest and money spent on KM there seems to be relatively few attempts to actually quantify the impact and results in business terms. The rationale is that knowledge exists in the context of its use [29]. Superior knowledge management frees companies to operate on fewer assets, collect their cash faster and have less volatility.⁸ The challenge is to make sure that the scope and the goal of the process is clear and focused, by providing a method to display indicators that measure objectives and a management. Given that KM requires a mix of technical skills: the mix and emphasis varies according to responsibility to be able to understand the business and communication approach to do this for KM could be the Balanced Scorecard.
- Text 6:** By creating a Balance Scorecard a company can gain understanding
- Text 7:** Van Grembergen and Timmerman [34] and Martinson et al [18] were some of the first to have suggested that the Balanced Scorecard can be the foundation for the strategic management of information systems in organizations. Martinson et al [18] use the balanced scorecard metrics to guide attainment of efficiency and effectiveness not only of information systems development but also of the use of the resulting information systems products in the operation of the business. They propose adaptations of the balanced scorecard framework based on the premise that IT is essentially an internal support function within an organization in contrast to the original framework, which focussed on the impact of the business on the external market. The same analogy might be used for KM, given knowledge supports the activities of the organization.
- Section Header:** Contribution of Balanced Scorecard to Knowledge Management Metrics
- Section Header:** Rationale for Balanced Scorecard in KM
- Text 8:** In their book The Balanced Scorecard, Kaplan and Norton [14] set forth a hypothesis about the chain of cause and effect that leads to strategic success. This cause and effect hypothesis could be fundamental to understanding KM metrics in a way that the balanced scorecard prescribes. Although the balanced scorecard can form the foundation for organizational strategic success, it is not sufficient in itself. Along with strategies, there must be initiatives, such as business process improvement efforts, to steer the organization in the right direction and improve KM implementation.⁶¹⁰
- Text 9:** Kaplan and Norton [14] distinguish Financial, Internal, Customer, and Learning and Growth perspectives on organizational processes essential to an overall strategy. In looking at the original Kaplan and Norton [14] implementation, Knowledge Management clearly fits within, if it does not define, the Learning and Growth aspect of their framework. If this is true, Knowledge

Figure 3. Screenshots of the Control Software

4 Research Questions

Based on the constructed theoretical framework, we formulated two main research questions to investigate the utility of the two attention-guidance functionalities we developed.

RQ1: What are the effects of faded instructor-led and peer-oriented attention-guidance functionalities in anchored discussion on:

- a) students' attention allocation in the instructional materials?
- b) students' message quality?
- c) students' interaction patterns?

RQ2: Do students' message quality and interaction patterns vary across time?

5 Methodology

To answer these research questions, we conducted an experimental study across three sections of a blended-format management information systems (MIS) course required for all business majors. The course teaches students how information helps to accomplish organizational goals and provides a strategic advantage for businesses. Participants were 150 third-year level business major students (77 female, 73 male) with an average age of 21.2 years ($SD = 2.13$). We split the students up into three classes of 50 students each. The same instructor taught all classes in parallel. We randomly assigned each class to a software system: 1) faded instructor-led attention-guidance functionality, 2) peer-oriented attention-guidance functionality, and 3) the control software. In each class, we spent one face-to-face session training students in the respective software system. Furthermore, we used this session to teach students the structural components of an argument based on the Toulmin (1958) argumentation framework before the experiment began to increase the quality of students' discussions in all three conditions. All three classes followed the same organizational structure in including four instructional materials that covered (in the order we present) the following topics: 1) "Strategy and business model: what is the difference?", 2) "Identifying user behavior in online social networks", 3) "Radio-frequency identification (RFID) applications in hospitals a case study on a demonstration RFID project in a Taiwan hospital", and 4) "Knowledge management metrics via a balanced scorecard methodology". We covered each topic during a two-week online discussion period. The learning task for all classes included two discussion activities. The first discussion activity asked students to annotate central concepts, principles, and their interrelations from instructional materials with underlying justifications. The second discussion activity asked students to collaboratively improve their tentative understanding of the central concepts, principles, and their interrelations from the texts. We required the students to participate in the online discussions in that it determined 30 percent of the course grade. The minimum participation requirement was to annotate two passages per topic and respond to at least two fellow students' messages for that topic. The instructor's visual marks in the faded instructor-led attention-guidance functionality (through changed font size) aimed to scaffold students' focused processing of central concepts, principles, and their interrelations (e.g., the interrelation between business benefits and challenges of RFID adoption in organizations). To help the instructor in the fading process, we analyzed the discussions while they were ongoing and reported our results back to the instructor during the course, who then adjusted his level of support accordingly. For the other groups, except for providing the topics for discussion, the instructor was not involved in any way unless students asked for help. When using the peer-oriented attention-guidance functionality, we additionally asked every student to use the importance bar at least once per topic to stimulate collaborative decision making on important points from the text.

5.1 Analysis of Students' Attention Allocation

We constructed qualitative heat maps to observe students' attention allocation from instructional materials during the experiment. The heat maps employed ClickTale Web service. At the input level, ClickTale Web service collected students' mouse movements (see Atterer, Wnuk, & Schmidt, 2006; Molenaar, van Bostel, Slegers, & Roda, 2011, for strong positive correlations between mouse movement and attention allocation). We recorded each topic during a two-week online discussion period. The maximum recording quota was 2380 per group for each topic. This fixed quota supported a maximum of 170 daily recordings. We selected a recording ratio of 20 percent to record each student's one of every five mouse movements randomly. The standardized colors on the heat maps ranged from red to blue with which we could compare students' attention allocation from instructional materials. Red suggests areas that received the most

student attention, yellow suggests areas that received less student attention, and blue suggests areas that received the least student attention in online discussions.

5.2 Analysis of Message Quality

We adopted the Gunawardena et al.'s (1997) content analysis instrument to assess the online discussions' message quality. The unit of content analysis was each complete message posted in the online discussion because students' messages were rather short and mainly comprised only one type of knowledge-construction phase (see Eryilmaz et al., 2013a, for the suitability of this analysis unit in similar settings). Table 2 summarizes five phases of knowledge construction based on Gunawardena et al.'s (1997) content-analysis instrument.

Table 2. Detailed Descriptions and Examples of Knowledge-construction Phases Based on Gunawardena et al.'s (1997) Content-analysis Instrument

| Phase | Description | Example |
|----------------------------|--|--|
| Sharing information | Statement of initial interpretation of a topic | <i>I think RFID has a big potential in the medical field. It can help reduce medical errors, if it can be ensured that the tags are provided with all the correct information. It can also increase medical efficiency by making information available a lot faster and easier. Quick accessibility to information is a very important factor in the medical field, especially during life and death situations, where a few key seconds can make all the difference in the world.</i> |
| Exploring dissonance | Identification of areas disagreement among interpretations | <i>No RFID is not a silver bullet because it is not supposed to be a solution for anything, it is rather an information technology that is made to support a business process. There is more that goes into the implementation of RFID than just the tags itself.</i> |
| Negotiating meaning | Modification of initial interpretations or clarification of different viewpoints | <i>I mean something like RFID cannot be implemented the same way in all organizations. Especially dealing with humans, RFID tags have to be adapted to people and how they behave. While it may work fine for tagging medical supplies and other objects to keep track of them, people may not appreciate being tagged themselves.</i> |
| Testing proposed synthesis | Evaluation of proposed synthesis against received facts, personal experience, or other sources | <i>A really good point brought up in this discussion is that unreliable RFID reads are not suitable for hospitals. For example, something as simple as water can interfere with RFID transmission. Recently in my TOM 301 class we had a lab regarding RFID tags and we observed that RFID does not work if the bottle has any content of water.</i> |
| Agreeing on new knowledge | Summarization of agreement(s) as a result of group discussion | <i>I agree with your statement that RFID tagging on persons is an ethical issue. I think it is wrong to tag staff and physicians because it invades their privacy.</i> |

5.3 Analysis of Students' Interaction Patterns

Although content analysis reveals understanding of individual message content in online discussions, merely using this method provides a limited inference on understanding how an idea becomes part of the larger discourse, which may influence a student's subsequent thinking. Thus, similar to fitting jigsaw puzzle pieces together, collaborative knowledge construction requires students to bring together a flow of interrelated ideas to build on each other's contributions. This sequential nature of discourse is important but seldom analyzed in information systems research (Eryilmaz et al., 2013a).

We carried out sequential analysis via the Discussion Analysis Tool (DAT) that Jeong and Frazier (2008) developed to examine students' interaction patterns. Two fundamental building blocks establish the conceptual foundation of sequential analysis. First, meaning does not reside in an isolated message.

Instead, meaning emerges from the sequential relationships of sharing information, exploring dissonance, negotiating meaning, and so forth. Therefore, every message becomes a link in a chain of thoughts. Second, meaning is re-negotiated and re-constructed during threaded discussions. Chronologically ordered messages coded in accordance with the content analysis instrument in Table 2 served as input for sequential analysis. Drawing on the above-mentioned conceptual foundation, DAT modeled students' interactions as two-event sequences (e.g., initial activity and its subsequent response) 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 (see Eryilmaz et al., 2014, for an analysis tracing longer sequences). We employed mean response scores to make statistical comparisons across the groups.

5.4 Analysis of Control Variables

At the beginning of the experiment, we examined students' prior domain-specific knowledge and attitude toward collaborative knowledge construction in online discussions as control variables because they could have direct effects on dependent variables. Regarding prior domain-specific knowledge, Helder, van Leijenhorst, Beker, and van den Broek (2013) report that students' prior knowledge has an impact on their attention allocation in instructional materials (see Scheiter & Gerjets, 2007, for a similar finding). We analyzed students' prior domain-specific knowledge with a test that contained four open-ended questions (e.g., "Explain in your own words what RFID means?"; "What are the benefits and challenges of implementing RFID in supply chain processes?"). Each student had 30 minutes to answer the questions without consulting any resources. To avoid any biases, two trained coders independently scored questions without knowing students' conditions. The coders followed a rubric that Raes, Schellens, de Wever, and Vanderhoven (2012) developed. The maximum score was 3 and the minimum score was 0 for each question. We added up all four questions to determine each student' domain-specific prior knowledge with a possible range from 0 to 12. Table 3 describes and exemplifies the coding categories to assess students' prior domain-specific knowledge.

Table 3. Scoring Rubric for Students' Prior Domain-specific Knowledge

| Score | Description | Example |
|-------|--|---|
| 0 | Students have incorrect or irrelevant ideas in the given context. | <i>I don't know how to define RFID. I heard some people use it to track their dogs in case they get lost. Is it also a tool to control quality? No clue.</i> |
| 1 | Students have some relevant and correct ideas but do not connect them in a given context. There are still incorrect and irrelevant ideas included in the answer. | <i>RFID is a piece of technology, a tool. I am unsure how RFID can organize a supply chain process. Maybe it is kind of a management to keep all products perfect quality.</i> |
| 2 | The answer is correct but rather isolated. Students still fail to connect the relevant ideas. | <i>RFID can somehow be identified as a technology resource that collects and transmits data. Many companies like Walmart use RFID to reduce the work their employees have to do. It must be a good idea!</i> |
| 3 | Scientific concepts are explained correctly and coherently as a token of a systematic understanding. | <i>I think RFID is an infrastructure technology that allows companies to keep track of objects. This technology can benefit both the employers and their customers by speeding up the work load and providing better information to their suppliers, customers, stockholders, etc. As with all technology there is a chance for failures or delays. For instance, if staff aren't willing or interested to learn and adapt to the new technology then the whole thing is useless.</i> |

Regarding attitude toward collaborative knowledge construction in online discussions, students in a CSCL setting do not simply react to instructional materials in isolation. Instead, they extend, deepen, and transform meanings by building on top of each other's ideas. However, if students' believe that collaborative knowledge construction in online discussions merely involves sharing information, they will engage in superficial interaction patterns rather than deep inquiry for collaborative knowledge construction (Scardamalia & Bereiter, 2006). We adopted the survey instrument that Chan and Chan (2011) validated to analyze students' attitude toward collaborative knowledge construction in online discussions. The survey

featured 12 questions. These questions measured how students themselves view their efforts as aligned with collaborative knowledge construction. More specifically, the survey focused on the following collaborative activities: improving tentative ideas, synthesizing different members' ideas into new knowledge, and assessing progress of understanding continually. Students answered the survey questions by using a five-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5). For each question, the participants had the option not to answer the question by selecting "N/A". In this respect, we collected data via self-report questionnaires that we asked students to complete at the beginning of the experiment.

6 Evaluation

We report our results in the order of our research questions. First, we evaluate the effects of faded instructor-led and peer-oriented attention-guidance functionalities in anchored discussion on students' attention allocation, message quality, and interaction patterns. Second, we examine the change in students' message quality and interaction patterns across time.

6.1 Evaluation of Student's Attention Allocation

As for RQ1a (the effect on students' attention allocation), the heat maps provided comprehensive pictures of students' attention allocation from instructional materials. Figures 4 and 5 portray two heat maps. The constructed heat maps display the attention allocation of all students for a single page. There is one heat map for every page of the instructional material both for the first discussion activity and for the second discussion activity. In total, we constructed 147 heat maps. In Figure 4, the instructor's guidance aimed to focus students' attention to the intangible benefits of RFID applications to hospitals, such as reducing medical errors and improving patient safety. Thirty-two students assigned to the faded instructor-led attention-guidance functionality group spent an average time of six minutes 22 seconds on this page. The red spots in Figure 4 reveal that students devoted the most attention to the instructor-determined important information and a sticky message summarizing a student's key idea for annotating that information (i.e., "further advantages of RFID").

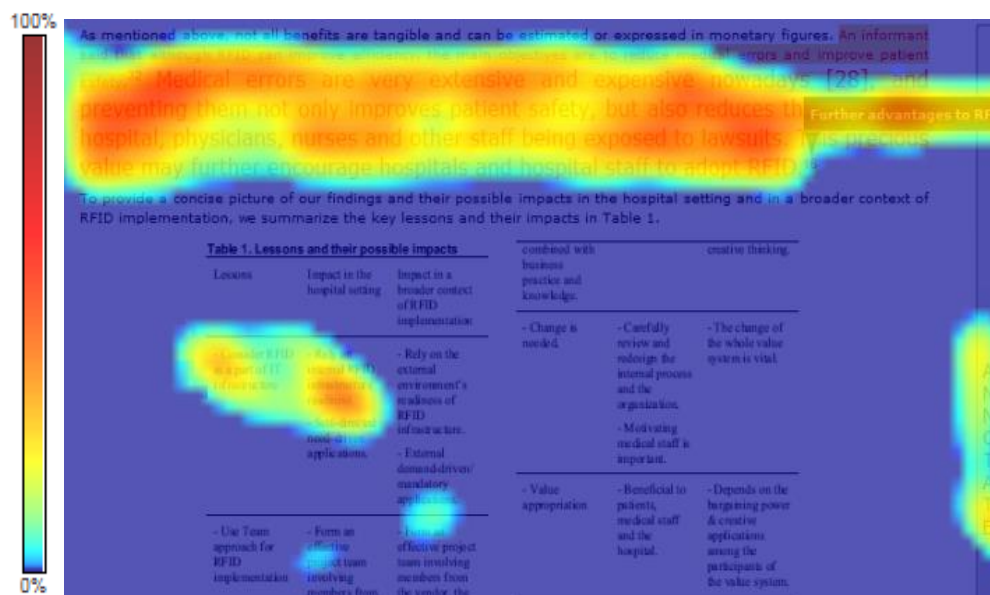


Figure 4. Heat Map for Faded Instructor-led Attention-guidance Functionality (RFID Applications in Hospitals: A Case Study on Demonstration RFID Project in a Taiwan Hospital Topic)

In Figure 5, the instructor's guidance aimed to focus students' attention to the business benefits and challenges of the K-means clustering algorithm to classify YouTube users. Twenty-nine students assigned to the faded instructor-led attention-guidance functionality group spent an average time of seven minutes 21 seconds on this page. The red spots towards the bottom of the page suggest that students devoted the most attention to the text summarizing business benefits of the K-means clustering algorithm and a student's

key idea for annotating that text (i.e., “clustering can be used to categorize many aspects of a wide variety”). Furthermore, although the information on the challenges of the K-means clustering algorithm received some student attention as suggested the orange spots in the middle of the page suggest, this visual stimulus did not induce a natural collaborative interaction. Instead, students’ annotated and discussed characteristics of a group determined by the K-means clustering algorithm (green, yellow, and orange spots at the top of the page in Figure 5).

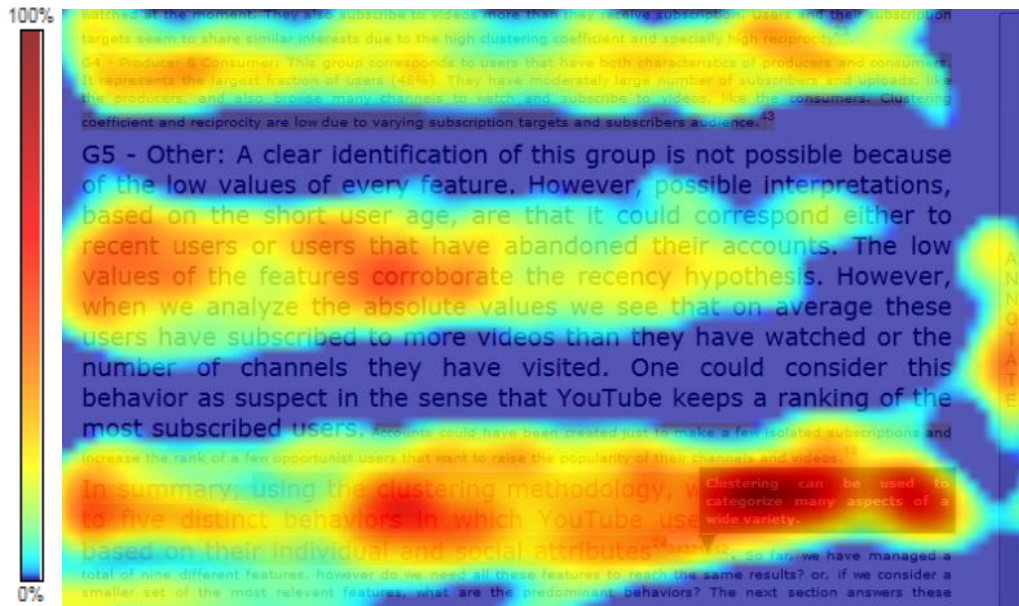


Figure 5. Heat Map for Faded Instructor-led Attention-guidance Functionality (Identifying User Behavior in Online Social Networks Topic)

Figures 6 and 7 illustrate two heat maps acquired from the peer-oriented attention-guidance functionality. In Figure 6, the larger font size represents peer consensus on the importance of motivating employees to create a collaborative knowledge-sharing culture in organizations. Thirty-four students assigned to the peer-oriented attention-guidance functionality spent an average time of eight minutes 5 seconds on this page. The red spots in Figure 6 expose the group’s focused attention around a student’s key idea (i.e., “implement rewards and acknowledgement to recognize knowledge workers achievements”) for annotating this collaboratively decided important information.

In Figure 7, students collaboratively recognized human capital, intellectual capital, structural capital, and social capital as important antecedents for building a knowledge-centric organization. Twenty-nine students assigned to the peer-oriented attention-guidance functionality spent an average time of seven minutes 32 seconds on this page. The red spots in Figure 7 suggest that the group paid the most attention to a student’s key idea (i.e., “these are the four capitals which make up a knowledge-centric organization”) for annotating the description of these antecedents. Moreover, orange, yellow, and green spots at the top of the page suggest a less-focused joint attention on another student’s annotation, which highlights measuring knowledge management with the following key idea: “measuring knowledge is difficult”.

Figures 8 and 9 present two heat maps acquired from the control software. Strikingly, both figures depict less student interaction with instructional materials’ central domain principles in online discussions. More specifically, these heat maps show that the control group’s attention was more distributed with respect to students’ annotations on text but less focused on any particular annotation, which the yellow and green spots suggest. In Figure 8, 27 students assigned to the control software spent an average time of five minutes 7 seconds to allocate minimal attention to each other’s annotations highlighting the following important points: basic purpose of RFID, possible inaccurate RFID reads, and design and deployment of RFID devices. Similarly, in Figure 9, 30 students assigned to the control group spent an average time of five minutes 43 seconds to allocate minimal attention to each other’s annotations highlighting the following important points: knowledge management benefits and rationale for a balanced score card in knowledge management.

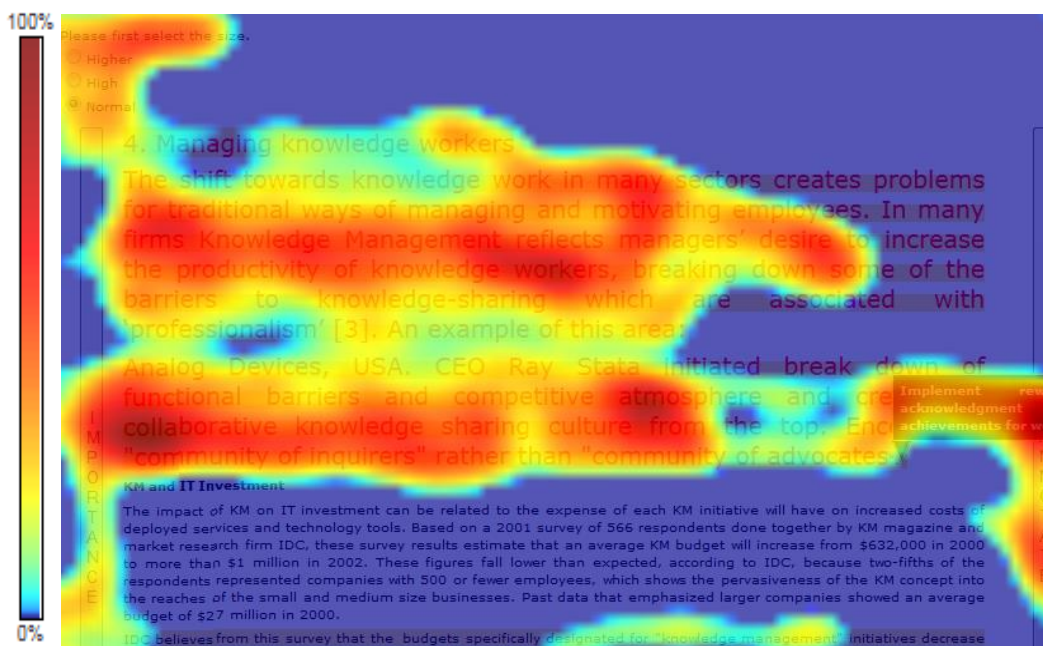


Figure 6. Heat Map for Peer-Oriented Attention-guidance Functionality (Knowledge Management Metrics via a Balanced Scorecard Methodology Topic)

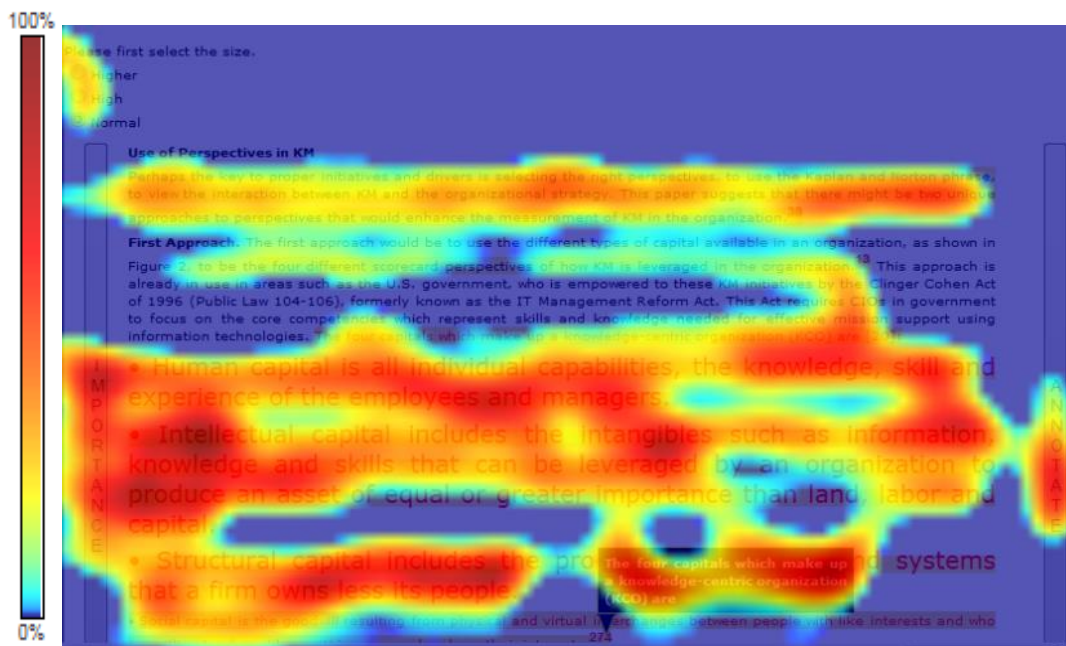


Figure 7. Heat Map for Peer-oriented Attention-guidance Functionality (Knowledge Management Metrics via a Balanced Scorecard Methodology Topic)



Figure 8. Heat Map for Control Software (RFID Application in Hospitals: A Case Study on a Demonstration RFID Project in a Taiwan Hospital Topic)

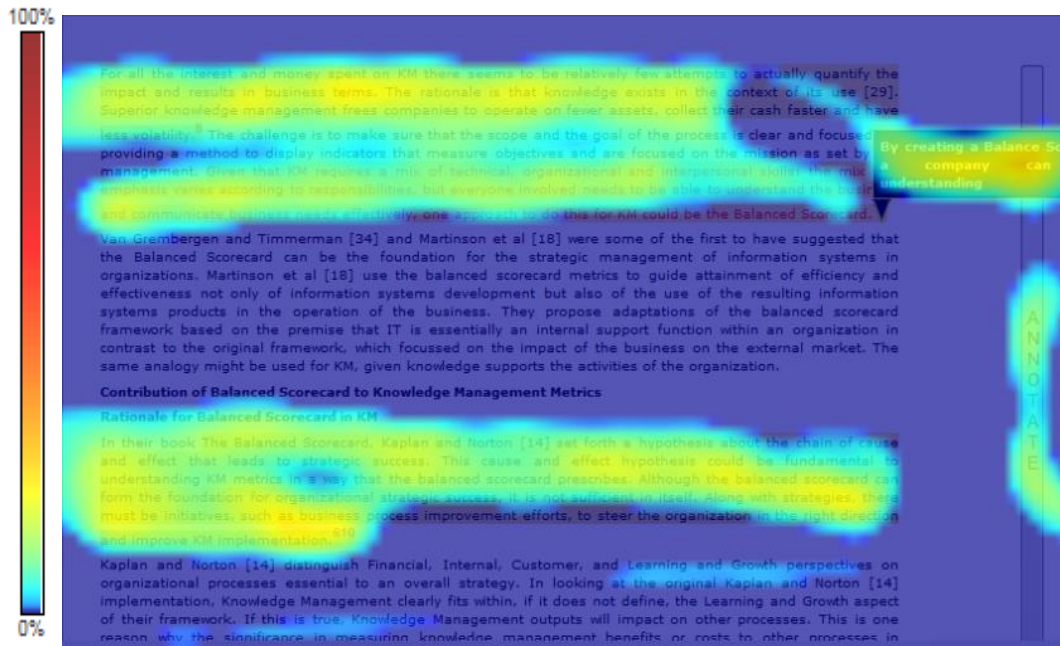


Figure 9. Heat Map for Control Software (Knowledge Management Metrics via a Balanced Scorecard Methodology Topic)

6.2 Evaluation of Message Quality per Student across Condition and/or Time

Twelve online discussions yielded a total of 2315 task-related messages for all the discussion groups. We trained three independent coders who were blind to the study's purpose to use Gunawardena et al.'s (1997) content analysis instrument 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-coder Krippendorff's alpha reliability was 0.74, which exceeds 0.67 and indicates a satisfactory agreement beyond chance. Coders resolved all disagreements via discussion.

For each discussion, we created message scores for each student for sharing information, exploring dissonance, negotiating meaning, testing proposed synthesis, and agreeing on new knowledge phases. For each student, we created these scores by dividing the frequency of posts of a given type by the total number of posts for a given discussion. For example, if a student posted a total of five messages for a given discussion and one of those posts was a negotiating-meaning post, that participant's negotiation score would be 0.20 (1/5).

To assess group differences in message scores across time, we conducted a repeated measures general linear model (GLM) analysis for each message score with one between-subject variable (group: control, peer-guidance, and instructional guidance) and one within-subject variable (discussion: 1-4).

6.2.1 Sharing Information Message Scores

Concerning RQ1b (the effect on students' message quality), students in the control group ($M = 0.47$, $SE = 0.02$) had higher sharing-information message scores than did participants in the faded instructor-led attention-guidance functionality group ($M = 0.33$, $SE = 0.02$) and peer-oriented attention-guidance functionality group ($M = 0.36$, $SE = 0.02$; Ryan-Einot-Gabriel-Welsch Range (REGWR) $p < 0.05$). There were no statistically significant differences between students' sharing information message scores in the faded instructor-led and peer-oriented attention-guidance functionality groups (REGWR $p = 0.12$).

Concerning RQ2 (change in students' message quality across time), we found a statistically significant interaction between group and discussion in that the group differences in sharing-information message scores varied across discussions ($F(6,441) = 3.56$, $p = 0.002$, $\eta^2_{\text{partial}} = 0.046$). The linear contrast computed on the discussion by group interaction was also statistically significant, which indicates that the linear relationship between sharing information message scores varied by group ($F(2, 147) = 7.61$, $p = 0.001$, $\eta^2_{\text{partial}} = 0.094$). Based on Figure 10 (next page), while the control group students tended to have higher sharing information message scores than the other groups, they also increased sharing-information message scores across discussions, while sharing scores tended to decrease across discussion for students in the faded instructor-led and peer-oriented attention-guidance functionality groups. For example, the effect size computed on group differences in sharing scores between the faded instructor-led attention-guidance functionality group and control group was $d = 0.31$ at discussion 1 and increased to $d = 1.01$ at discussion 4. Similarly, the effect size computed on group differences between the control group and peer-oriented attention-guidance functionality group increased from $d = 0.27$ at discussion 1 to $d = 0.44$ at discussion 4. In sum, these findings indicate that the control group relied on sharing information messages to a larger extent than students in the other conditions and that they sustained this reliance to a greater extent across discussions, while the opposite pattern of findings was uncovered for students in the other groups. Appendix A presents examples of sharing information messages from a discussion thread in the control group.

6.2.2 Exploring Dissonance Message Scores

Concerning RQ1b (the effect on students' message quality), we found statistically significant group differences in exploring dissonance message scores ($F(2, 147) = 9.97$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.119$). Specifically, the control group ($M = 0.16$, $SE = 0.02$) had lower exploring dissonance message scores on average than the peer-oriented attention-guidance functionality group ($M = 0.26$, $SE = 0.02$) and faded instructor-led attention guidance-functionality group ($M = 0.28$, $SE = 0.02$; REGWR $p < 0.05$). We found no statistically significant difference in exploring dissonance message scores for the peer-oriented attention-guidance functionality group and faded instructor-led attention-guidance functionality group (REGWR $p = 0.351$). The group by discussion interaction was not statistically significant ($F(6, 441) = 0.80$, $p = 0.567$, $\eta^2_{\text{partial}} = 0.011$).

Concerning RQ2 (change in students' message quality across time), a linear contrast computed on exploring dissonance scores across discussions was statistically significant ($F(1, 147) = 22.12, p < 0.001, \eta^2_{\text{partial}} = 0.131$). As Figure 11 shows, mean exploring dissonance message scores tended to increase across discussion. The group by discussion interaction for the linear contrast was not statistically significant ($F(2, 147) = 1.07, p = 0.346, \eta^2_{\text{partial}} = 0.014$). Taken together, these findings indicate that students in the faded instructor-led and peer-oriented attention-guidance functionality groups tended to have higher exploring-dissonance message scores than the control group, and their scores tended to increase across discussion. Appendices B and C present examples of exploring dissonance messages from two discussion threads in the faded instructor-led and peer-oriented attention-guidance functionality groups.

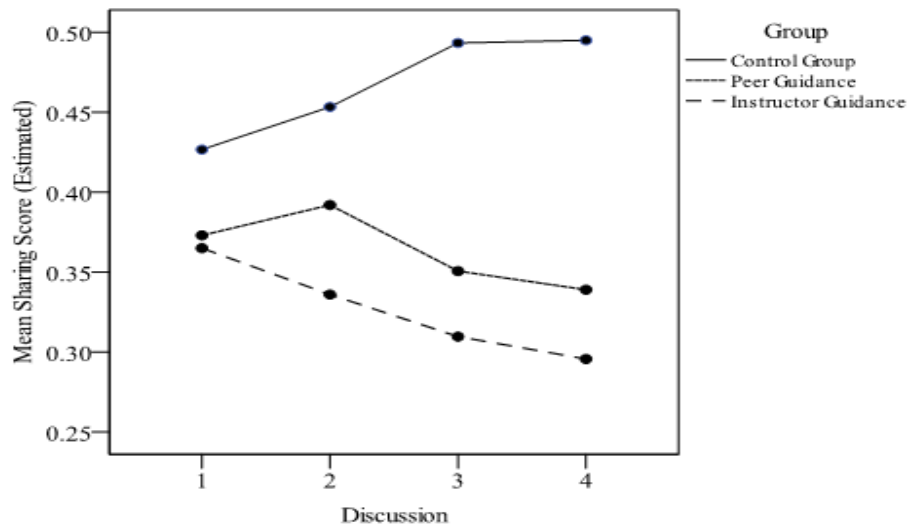


Figure 10. Mean Sharing Information Message Scores by Group and Discussion

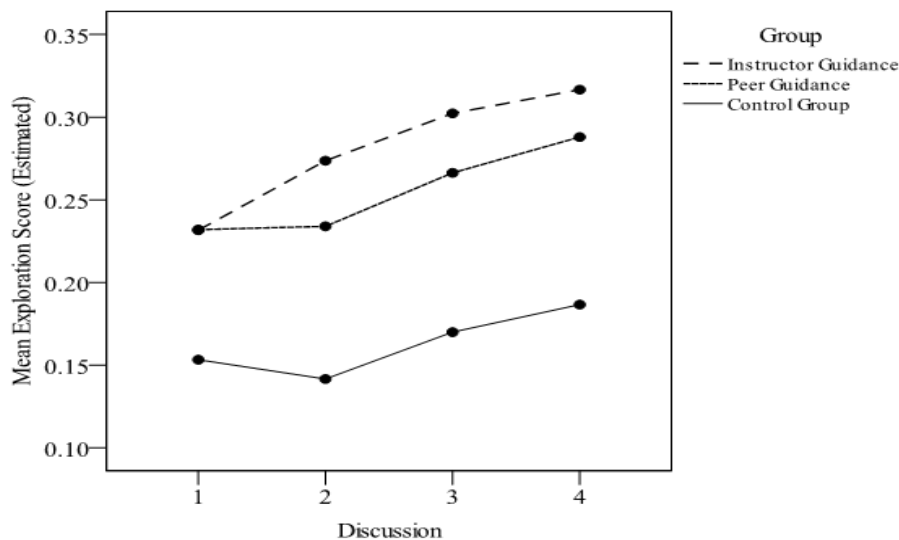


Figure 11. Mean Exploring Dissonance Message Scores by Group and Discussion

6.2.3 Negotiating Meaning Message Scores

Concerning RQ1b (the effect on students' message quality), we found statistically significant group differences in students' negotiating meaning scores ($F(2, 147) = 10.86, p < 0.001, \eta^2_{\text{partial}} = 0.129$). Specifically, students in the control group ($M = 0.17, SE = 0.02$) had significantly lower negotiating meaning scores on average than students in the peer-oriented attention-guidance group ($M = 0.29, SE = 0.02$) and faded instructor-led attention-guidance group ($M = 0.28, SE = 0.02$; REGWR $p < 0.05$). We found no statistically significant group differences in negotiating meaning scores across the faded instructor-led attention-guidance and peer-oriented attention-guidance groups (REGWR $p = 0.748$).

Concerning RQ2 (change in students' message quality across time), group differences in negotiating meaning message scores did not significantly vary across discussion ($F(2, 147) = 1.78, p = .173, \eta^2_{\text{partial}} = 0.024$). Overall, these findings indicate that the control group students posted a smaller proportion of negotiating meaning messages than the other groups and that this pattern was more or less consistent across discussion. Appendix C presents examples of negotiating meaning messages from a discussion thread in the peer-oriented attention-guidance group.

6.2.4 Testing Proposed Synthesis/Agreeing on New Knowledge Scores

We had insufficient data to assess message scores across discussions for testing proposed synthesis scores and agreeing on new knowledge scores. Thus, we collapsed message scores across discussions and analyzed them with an independent samples median test. We found no statistically significant group differences in message scores for testing proposed synthesis scores ($p = 0.121$) or agreeing on new knowledge scores ($p = 0.245$).

6.3 Evaluation of Students' Interaction Patterns in Online Discussions among Software Systems

Concerning RQ1c (the effect on students' interaction patterns), we chronologically ordered all 2315 task-related messages and conducted a series of ANOVAs. Table 4 presents three descriptive statistics metrics to identify statistically significant group differences. The first metric, sample size, indicates the number of messages that triggered responses. For example, messages coded as exploring dissonance triggered 167 responses in the peer-oriented attention-guidance group. The second metric, mean, represents the mean number of a specific response type produced by a message. For example, a message coded as exploring dissonance produced a mean number of 1.35 negotiating meaning responses in the peer-oriented attention-guidance group. The last metric, standard deviation, shows how widely instances of a message category vary for the production of a specific response type. For example, the variation among the instances of an exploring dissonance message category to producing a negotiating meaning response was 1.13 in the peer-oriented attention-guidance group.

We found 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 4). Follow-up simple effects testing uncovered that 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-led attention-guidance functionalities (all $ps < 0.002$, all $ds > 0.35$). Moreover, the control group had a significantly greater amount of exploring dissonance to sharing information sequences than the groups assigned to peer-oriented and faded instructor-led attention-guidance functionalities (all $ps < 0.001$, all $ds > 0.49$). Finally, the control group had significantly fewer negotiating meaning to negotiating meaning sequences than the group assigned to the peer-oriented attention-guidance functionality ($t(460) = 3.52, p < 0.001, d = 0.33$). Concerning group differences in two-event sequences for the peer-oriented and faded instructor-led attention-guidance functionalities, the group assigned to the peer-oriented attention-guidance functionality had a greater amount of negotiating meaning to negotiating meaning sequences than the faded instructor-led attention-guidance functionality group ($t(614) = 5.46, p < 0.001, d = 0.36$). Appendix C presents an example of a negotiating meaning to negotiating meaning sequence from a discussion thread in the peer-oriented attention attention-guidance group.

Table 4. Sequence Analysis Results

| Two-event Sequences | Control group | | Faded instructor-led attention-guidance functionality group | | Peer-oriented attention-guidance functionality group | | ANOVA | | | |
|--|----------------|----------|---|----------|--|----------|-----------|----------|----------|----------|
| | <i>M</i> (SD) | <i>N</i> | <i>M</i> (SD) | <i>N</i> | <i>M</i> (SD) | <i>N</i> | <i>df</i> | <i>F</i> | η^2 | <i>p</i> |
| Sharing information → exploring dissonance | 0.19 (0.47) | 352 | 0.43 (0.74) | 320 | 0.40 (0.7) | 284 | 2,2943 | 13.99 | 0.03 | <0.001 |
| Exploring dissonance → negotiating meaning | 0.96 (0.96) | 125 | 1.61 (1.42) | 158 | 1.35 (1.13) | 167 | 2,2447 | 10.28 | 0.04 | <0.001 |
| Exploring dissonance → sharing information | 0.94 (1.08) | 125 | 0.42 (0.8) | 158 | 0.46 (0.88) | 167 | 2,2447 | 13.55 | 0.06 | <0.001 |
| Negotiating meaning → negotiating meaning | 0.05 (0.22) | 136 | 0.01 (0.39) | 290 | 0.26 (0.68) | 326 | 2,2749 | 19.41 | 0.05 | <0.001 |

6.4 Evaluation of Students' Interaction Patterns in Online Discussions across Time

Concerning RQ2 (change in students' interaction patterns across time), we found one significant interaction pattern in online discussions across time. While we found 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 sequences than the control and faded instructor-led attention-guidance functionality groups during the last discussion ($t(133) = 1.99$, $p = 0.049$, $d = 0.46$; $t(169) = 2.057$, $p = 0.04$, $d = 0.33$, respectively). Furthermore, we found 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 sequences than the control and faded instructor-led attention-guidance functionality groups ($t(127) = 1.98$, $p = 0.05$, $d = 0.46$; $t(170) = 1.94$, $p = 0.054$, $d = 0.34$, respectively) (see Figure 12 for a visual depiction).

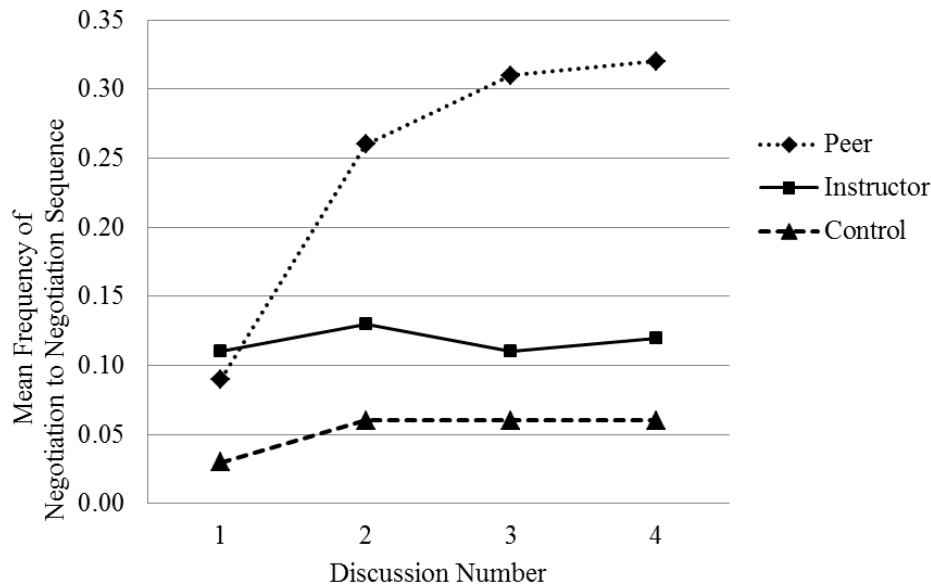


Figure 12. Mean Frequency of Negotiating Meaning to Negotiating Meaning Sequences as a Function of Group and Time

6.5 Evaluation of Control Variables

The Krippendorff's alpha inter-rater reliability measure for the coding of the prior knowledge test was 0.82, which indicates high inter-coder reliability. Students' prior domain-specific knowledge scores in the three groups were $M = 3.96$, $SD = 1.54$ for the control group, $M = 4.04$, $SD = 1.23$ for the faded instructor-led attention-guidance group, and $M = 4.00$, $SD = 1.51$ for the peer-oriented attention guidance group. A one-way between subjects ANOVA revealed no significant difference in prior domain-specific knowledge scores among the three groups, $F(2, 147) = 0.04$, $p = 0.96$. Students' attitude towards collaborative knowledge construction in the three groups were $M = 3.59$, $SD = 0.40$ for the control group, $M = 3.49$, $SD = 0.45$ for the faded instructor-led attention guidance group, and $M = 3.41$, $SD = 0.48$ for the peer-oriented attention guidance group. A one-way between subjects ANOVA revealed no significant difference in students' attitude toward collaborative knowledge construction in online discussions among the three groups ($F(2, 147) = 1.94$, $p = 0.15$). Therefore, control variables were not different among the groups at the beginning of the experiment.

7 Discussion

To measure our proposed theoretical framework, we asked two research questions about the effects of faded instructor-led and peer-oriented attention-guidance functionalities in anchored discussions. Our dependent variables were students' attention allocation in instructional materials, message quality, and interaction patterns. Table 5 represents a snapshot of our research findings.

Concerning RQ1a (the effect on students' attention allocation), the investigated heat maps show not only that both forms of attention guidance helped students pay more attention to central domain principles in text but also that their overall attention was more focused and less fragmented. However, without some form of guidance, students seem to have been distracted more by less-relevant details. These distractions, depicted by the yellow and green spots in Figures 8 and 9, may have led students to pay attention to details at the expense of central domain principles. Overall, these findings suggest that merely providing instructional materials in online discussions does not add much value to the conversation. As we explain through the lens of our theoretical framework, attention guidance influences students' cognitive processes that explicitly identify new relevant information on which to concentrate. Therefore, students deliberately select central domain principles from the text, which otherwise might not occur. As Mayer (1999) has noted, this deliberate selection serves as the foundation for students' subsequent cognitive processing of central domain principles from the text. Whereas the effects of the instructor-generated font size changes on students'

attention allocation were straightforward, the student-generated font size changes had an interesting effect: students focused more not only on parts of the text with bigger font size but also on parts with smaller font size. We interpret this result as a sign that students are not ready to simply accept each other's judgments on what is more or less important without further probing and double checking and discussing these judgments from their peers first. Thus, they seem to collaboratively decide on the central domain principles before "storing" that decision in a changed font size. As this collaborative negotiation was exactly the goal of our peer-oriented attention guidance, the presented result support that our IT artifact provided affordances for students to become (even more) aware of the importance of allocating proper attention during online discussions of instructional materials.

Table 5. Summary of Results

| | |
|--|---|
| RQ1: What are the effects of faded instructor-led and peer-oriented attention-guidance functionalities in anchored discussion on: | |
| a) students' attention allocation in the instructional materials? | Teacher-increased font size of central domain principles increased students' attention on those principles. When using the importance bar, students paid more attention to peer-increased and peer-decreased font sizes. |
| b) students' message quality? | Both forms of attention-guidance functionalities decreased the sharing of information but increased the exploring dissonance and negotiating meaning. |
| c) students' interaction patterns? | Both forms of attention-guidance functionalities increased two interaction patterns: sharing information to exploring dissonance and exploring dissonance to negotiating meaning. Furthermore, the peer-oriented attention-guidance functionality increased negotiating meaning messages following other negotiating meaning messages. |
| RQ2: Do students' message quality and interaction patterns vary across time? | Regarding message quality, both forms of attention-guidance functionalities decreased the sharing of information and increased exploring dissonance across time. Regarding students' interaction patterns, peer-oriented attention-guidance increased students' negotiating meaning messages following other negotiating meaning messages across time. |

Concerning the method we used to collect data for this research question, the investigated heat maps extend van der Pol et al.'s (2006) measurement of students' perceived use of instructional materials in online discussions by opening the black box of their attention allocations in instructional text. The unique combination of using anchored discussion—which integrates discussion and text on screen—and mouse tracking software has made this extension possible.

Concerning RQ1b (the effect on students' message quality), our analysis of students' message types demonstrates that control group students produced new ideas much more than they attempted to refine existing ones (by either exploring dissonance or negotiating meaning). This finding is line with prior research (e.g., De Wever, Schellens, Valcke, & van Keer, 2006; Schellens & Valcke, 2005; Wise & Chiu, 2011) and it resonates with Scardamalia and Bereiter's (2006) remark that "generating ideas appears to come naturally to people, especially children, but sustained effort to improve ideas does not" (p. 100). From a social constructivist perspective, this finding that both forms of attention guidance facilitated fewer sharing information messages but more exploring dissonance and negotiating meaning messages is very important because the latter represent the "higher"-order activities that are indispensable for collaborative knowledge construction (Gunawardena et al., 1997).

One explanation for this finding is that, if discussion threads do not start with an articulation of a genuine comprehension difficulty focusing on relevant information, subsequent messages do not extend, deepen, or transform meanings. Turning back to our theoretical framework, this finding supports our argument that sharing tentative ideas focusing on central domain principles can serve as triggers for deep collaborative processing of those principles in discussion threads. For example, we can consider Figures 8 and 9

symptoms of control group students' difficulty to concentrate on central domain principles. Appendix A stresses that, under such conditions, control group students started their discussion threads with superficial messages and their discussion threads did not live up to the promise of rich interactivity. However, differing from the control group, Figures 4, 5, and Appendix B exhibit that the instructor's increasing the font size encouraged students to openly acknowledge their common confusions, which sparked topic-related questions. Normally, in discussions without instructors' identifying important sections, students may more easily be inclined to ignore their confusions about certain parts due possibly to their insecurity on whether the section or message they are confused about or disagree with is actually worth discussing. The instructor-identified importance may be the small nudge they need to address things they do not (fully) understand or agree with that they otherwise may ignore. In addition, this finding suggests that students did not associate the instructor's guidance with a threat to self-esteem or threat to autonomy that has sometimes been shown to subdue student-to-student interaction (Karabenick, 2011). From a design science perspective, this finding underscores the effectiveness of the IT artifact at hand. If the instructor's voice had been more directly and more strongly present by actively taking part in the discussion itself, that may still have had such a subduing effect (see Race, 2013 and Zahn et al., 2012, for such findings).

Concerning RQ1c (the effect on students' interaction patterns), which relates to the previously discussed difference in message types, we found differences in the sequence of messages. To begin with, both forms of attention-guidance functionalities showed more exploration of dissonance that followed information sharing. Also, more negotiating meaning followed the exploration of dissonance. We consider these interaction patterns constructive (as we define earlier) because they show clearly how students built on, refined, and modified existing ideas while focusing on understanding of their instructional materials' central domain principles (Baker, 1999). Furthermore, the finding that these interaction patterns did not differ significantly between both attention-guidance functionalities is noteworthy because it shows that they both supported students in thinking deeply about the relevance of the instructional materials' content to the current learning activities by asking how and why questions (Jeong & Hmelo-Silver, 2010).

Moreover, peer-oriented attention-guidance functionality increased negotiating meaning messages following other negotiating meaning messages. This interaction pattern indicates a sustained creative work to improve tentative ideas (see Appendix C). As a key tenet of constructing social knowledge, this interaction pattern seems to reflect the fact that students dropped false points of view or modified initial ideas when they received guidance from their peers. For online discussions in an educational context in particular, this is of great importance because collaborative learning is thought to occur through negotiating meaning with others (Gunawardena et al., 1997). We attribute this important finding to the extra effort students invested into using the importance bar functionality. Even if we would not have asked students to use the importance bar at least once, its mere presence could still be considered an additional "task" because even just offering the functionality can imply the didactic message or suggestions to the students that they should use it. Contrasting this important finding with faded-instructor guidance, the results suggest that students did not always understand the reasons behind the importance of a central domain principle that the instructor suggested. This explanation is in line with the description of the heat map in Figure 5, which shows that the instructor's guidance did not always induce students' natural interaction on central domain principles. In such situations, students were unable to use their learning partners as resources.

Taken together, the answers to RQ1a, RQ1b, and RQ1c indicate that the effectiveness of attention guidance in online discussions depends on quality of students' reflection of their peers' ideas that focus on relevant information with use of the collaborative-learning cycle described in the theoretical framework. In this vein, this study contributes to solving the discrepancy in the literature concerning the effects of attention guidance on deep processing of relevant information (for a detailed review of the discrepancy, see Dodd & Antonenko, 2012).

Concerning RQ2 (change in students' message quality and interaction patterns across time), we found that both forms of attention-guidance functionalities decreased the sharing of information messages and increased the exploring of dissonance messages across time. From a social constructivist perspective, this finding supports Hewitt's (2005) remark that engaging students in inquiries regarding tentative ideas is difficult to cultivate. Particularly, asking cognitively demanding questions (e.g., "Would you not say that it is experience, not knowledge, that is the ultimate competitive advantage?") requires students to concentrate on both the instructional material's relevant information and peers' tentative ideas focusing on that information. Our interpretation of this positive trend is that students were initially reluctant to critique or be critiqued for fear of making mistakes. But, as they realized that they had common misunderstandings and confusion about the text, they began to identify gaps in understanding the important ideas of the instructional

material. Therefore, students concentrated on deep processing of the information they realized to be important instead of wasting time searching for new information. In accordance with our theoretical framework, exploring dissonance laid the foundation to establish meaningful negotiations through deconstructing and reconstructing tentative ideas (Gunawardena et al., 1997), a point to which we will turn next.

We found that the peer-oriented attention-guidance functionality increased students' negotiating meaning messages following other negotiating meaning messages across time. We can interpret this trend (see Figure 12 depicts) as students' growing willingness to improve existing tentative ideas or to offer alternative explanations by reflecting on both their own and other group members' perspectives instead of jumping into conclusions inconsistent with instructional materials' central domain principles. This is an important finding because students in online discussions tend to choose the easier option of jumping to conclusions, which are often then inconsistent with instructional materials' central domain principles (Kim & Hannafin, 2011). From a social constructivist standpoint, such improvements are the essence of collaborative learning because they represent students' deliberate efforts to develop deep understanding of an instructional material being discussed (Lin & Tsai, 2012). A possible explanation of this important trend is that, when students supplemented their messages with a variable font size in text, they effectively captured their learning partners' attention to reconsider their existing ideas and construct new understandings. By contrast, when students received guidance from the instructor, they had fewer negotiating meaning messages following other negotiating meaning messages across time. This contradictory finding underscores the difficulty of sustaining students' effort to improve tentative ideas in online discussions (Hewitt, 2005). Under such situations, online discussion depth is considered to be insufficient for students to detect gaps in understanding, which negatively affects their learning (e.g., De Wever et al., 2006; Gunawardena et al., 1997; Schellens & Valcke, 2005; Wise & Chiu, 2011). A possible explanation of this contrasting behavior is that students ended their discussion threads when the first plausible explanations of why instructor-determined central domain principles were important arose instead of further advancing those explanations by comparing and contrasting different views.

8 Limitations

We acknowledge that our study has certain limitations. First, our results' generalizability is limited to low prior domain-knowledge students' processing of scientific texts that do not offer the visual aid of identifying key terms and principles. Both the need and effect of attention guidance may be less when using educational texts that present key terms in a bold font. Furthermore, although the particular domain in this study was information systems, we think that the results are applicable to any other domain where students face similar problems with proper attention allocation. Students can profit the most from attention guidance if online discussions are successfully implemented and executed. In other words, the more active a discussion is, the more that activity can be focused by attention guidance and the stronger we can expect its effect to be.

Second, offering students in the peer-oriented attention-guidance condition an importance rating bar and asking them to use it at least once presents students with a small additional task. This small extra task could have required students to invest (even) more effort into identifying relevant parts of the text, and, therefore, we can hold it responsible for part of the results. However, instead of being an inequality of conditions, we view this small extra task as an integral part of our peer-oriented attention-guidance functionality and, indeed, as an essential part of why it works. Thus, we view the importance rating bar in the peer-oriented attention-guidance functionality as offering two major influences on students' collaboration: 1) it makes students (even more) aware of the importance of proper attention allocation and 2) it engages them in a (small additional) task to collaboratively determine and keep track of what is important while, at the same time, offering them the technical means to do so.

Third, while our ultimate goal was to improve learning, we did not measure individual learning results. Constructivist learning is difficult to measure because it not only holds variance on many variables (for a comprehensive list see Kirschner, Martens, & Strijbos, 2004) that influence learning but also involves measures more difficult than traditional tests (e.g., long-term application in practice and transfer to new domains). Since this is the first investigation of two innovative artifacts, we chose our independent and dependent variables more closely together to search for a link between attention guidance and quality of collaborative knowledge building. However, now that we have found such a link indeed exists, we plan to investigate the effects of attention guidance on learning results in our future study.

9 Conclusion

In this paper, we construct a theoretical framework on the basis of social constructivist literature to identify two forms of attention guidance in online learning conversations. We used the attention-guidance functionalities to direct students' attention towards instructional materials' central domain principles while offering them an open learning environment in which they could choose their own topics and express their own ideas (see Thoms & Eryilmaz, 2014, for the design of a similar system). Overall, the results demonstrate that attention-guidance functionalities can help students more properly allocate their attention in online learning conversations. Furthermore, this improved attention allocation can lead to better quality of students' collaborative knowledge building. From a theoretical perspective, this is an important contribution because the relationship between attention guidance and quality of collaborative knowledge building had previously been untested by existing models of learning (Engelmann, Dehler, Bodemar, & Buder, 2009). Through understanding this relationship, instructors can use new ways to prepare students for managing inter-professional expertise and constructing new knowledge collaboratively in real-world projects.

We invite the research community to apply and further investigate the validity of our theoretical framework. For example, the framework can be tested in computer-supported collaborative learning and computer-supported collaborative work settings due to many similarities between the two, such as explicating thoughts, actively discussing views, and coordinating actions (Kirschner & Erkens, 2013). This can be done by applying it with different configurations of students- and working-teams' attention allocations and knowledge-construction activities (e.g., Pena-Shaff & Nicolls, 2004; Weinberger & Fischer, 2006).

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Appendix A: Examples of Sharing Information Messages from a Discussion Thread in the Control Group

| Student annotated text | MessageID | Author | Content | Code |
|--|-----------|------------|---|---------------------|
| <p><i>It is considered the next revolution in supply chain management [32]. Current research and development on RFID focuses on manufacturing and retail sectors to improve supply chain efficiency and learn more about consumer behavior. There are problems still waiting to be resolved, including standard settings, technical limitations, software/middleware development, systems integration, higher costs, benefit appropriation among participants, privacy issues etc. [23, 32]. Nevertheless some firms are implementing RFID on a small scale and many firms are joining together to develop and promote the technology.</i></p> | 428 | Student 28 | <p><i>RFID basically stands for Radio Frequency Identification, meaning it is a small chip that transmits a weak radio frequency that is used to identify whatever the chip is attached to. This technology is used to trace its location and where the object has been.</i></p> | Sharing information |
| | 429 | Student 41 | <p><i>Privacy issues arise with the use of RFID. Some use it to track their dogs in case they get lost. It is used in hospitals to track patients as shown here. Will companies and schools start to use them to track their employees and students? What about the government? The door is open to some pretty disturbing privacy issues with the use of RFID.</i></p> | Sharing information |
| | 430 | Student 8 | <p><i>It says here that RFID is a very useful technology resource that collects and transmits data and a business can integrate in their daily usage. It is also claimed that RFID reduces labor costs of scanning items.</i></p> | Sharing information |

Appendix B: Examples of Exploring Dissonance Messages from a Discussion Thread in the Faded Instructor-led Attention-guidance Functionality Group

| Student annotated text | MessageID | Author | Content | Code |
|--|-----------|--------|---|----------------------|
| <p><i>Identifying user behavior within an environment in which we know nothing a priori is a challenging task and also an empirical process. We use K-Means, an unsupervised clustering algorithm, to find the clusters. The algorithm, by definition, runs without any optimization criterion or feedback [9, 13, 15]. Thus, there is no right or wrong number of clusters to find.</i></p> | 700 | 70 | <i>I have read through this but I still don't see how k-means cluster can improve business and resource management.</i> | Exploring dissonance |
| | 701 | 81 | <i>Most businesses are forced to predict customer wants or likes and the majority of them even spend money trying to figure out this information through resources like customer surveys and questionnaires. So being able to track and identify user behaviors is an extreme advantage for online social networks. It makes marketing and advertising much easier as well as being able to maintain a site that appeals directly to its users.</i> | Sharing information |
| | 702 | 96 | <i>But how is it possible to summarize our human thought to 5 distinct behaviors and attribute them correctly when users change their routines often? I think researchers would need to study users for a longer period of time.</i> | Exploring dissonance |

Appendix C: Examples of a Negotiating Meaning to Negotiating Meaning Sequence from a Discussion Thread in the Peer-oriented Attention-guidance Functionality Group

| Student annotated text | MessageID | Author | Content | Code |
|--|-----------|-------------|--|----------------------|
| <p><i>Knowledge has become the key economic resource and the dominate and perhaps even the only source of competitive advantage.</i></p> | 614 | Student 141 | <p><i>Would you not say that it is experience, not knowledge that is the ultimate competitive advantage? I think it experience, not knowledge that is the integral key to competitive advantage. You can have knowledge about your competition, products, business model etc. but without experience to actually apply this knowledge it is useless. This is similar to the concepts of data and information. Where data is meaningless until it is processed and organized into information</i></p> | Exploring dissonance |
| | 616 | Student 129 | <p><i>I believe that is called tacit knowledge, which seems to be a vast storage of knowledge based on a person's experiences. Tacit knowledge is a huge competitive advantage when used correctly. A business can better manage its intellectual capital by uncovering the tacit knowledge of its employees and turning it into explicit knowledge, making it available to others.</i></p> | Negotiating meaning |
| | 617 | Student 112 | <p><i>Perhaps this is why the definition of knowledge is complex. My take is that it is up to the organization to determine what knowledge is. Furthermore, knowledge can be defined as facts, information, and skills acquired by a person not only through experience, but also through education.</i></p> | Negotiating meaning |

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