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Task Oriented Reading of Instructional Materials and Its Relationship to Message Scores in Online Learning Conversations

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Abstract

This paper examines the utility of an unobtrusive attention guidance functionality integrated into an anchored discussion system. Our proposed design is founded in social constructivism and accomplishes two objectives: (1) to promote students' task oriented reading of central domain principles from instructional materials; (2) to support students' progressive improvement of tentative ideas focusing on central domain principles from instructional materials. We perform experimental research to test our design and apply quantitative techniques to rigorously evaluate the utility of the developed attention guidance functionality. Results show that attention guidance prompted students to reflect on and monitor their cognitive processes while reading information they deemed important. Moreover, we found that students invested deliberate efforts to improve tentative ideas by focusing on information they deemed important. Finally, we discovered such efforts to be a significant predictor of task oriented reading of central domain principles from instructional materials. Theoretical and practical implications are outlined.

1. Introduction

An integral part of real-world information systems (IS) projects centers on knowledge intensive collaboration between IS professionals and business users. Amongst other things, collaboration promotes a shared understanding of technical requirements, which helps to mitigate expensive and time consuming rework [1]. The true essence of collaboration involves explicating ideas, negotiating disparate perspectives, and coordinating actions to complete each phase of a project, resulting in knowledge construction [2]. A survey of industry perceptions and industry needs underscores that effective collaboration is an important interpersonal skill for an entry-level information systems professional's growth within an organization, whether it be to remain an entry employee or to be promoted to a more senior role [3]. For IS educators, collaborative learning attempts to mirror the industry by challenging students to continuously improve ideas via group interactions. As noted by Kruck and Teer [4], collaboration should be treated as a core technical skill, such as programming, database, and telecommunications in order to prepare students for the real-world challenges of IS projects.

Computer-supported collaborative learning (CSCL) systems offer a rich array of affordances for students to practice continuous improvement of ideas [5]. As stated by Pena-Shaff and Nicholls [6], asynchronous online discussion (AOD), in particular, prompts students to review posted messages and analyze their own ideas before responding because they are not constrained to respond immediately. As a specialized form of AOD, anchored discussion links or anchors messages to specific highlighted and numbered passages in a text, which helps to contextualize students' ideas. This tight coupling makes an anchored discussion especially suitable for the collaborative processing of academic literature. Prior research evaluating the utility of anchored discussions demonstrates that the above mentioned tight coupling increases communicative efficiency and overall quality of context-oriented communication [e.g., 7, 8, 9, and 10]. Along this line, Eryilmaz et al. [11] showed that the increase in communicative efficiency allows students to dedicate more time and effort for demanding knowledge construction activities that positively associate with individual learning outcomes [see 12 for similar learning findings].

Despite these potentials, anchored discussion systems do not always produce rich learning interactions [13, 14]. A major challenge noted by a succession of studies is the students' shallow processing of central concepts, principles, and their interrelations from instructional materials [15, 16, 17, 18]. Specifically, more detailed analysis of discussion threads shows that as the subject matter increases in difficulty, students become less comfortable posing questions that expose their lack of understanding and students offer ideas that later turn out to be incomplete

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or incorrect [15, 17, 19, and 20]. In such cases, progressive improvement of tentative ideas becomes difficult and as a result, students can develop robust and oversimplified misunderstandings that prove highly resilient to change [21]. In other words, merely contextualizing students' ideas in anchored discussions is insufficient to ensure learning. Thus, an overarching question arises, how can AOD designers unobtrusively focus students' attention on the progressive development of ideas in areas where students struggle to gain understanding from instructional materials?

To answer this subtle and complex question, we employ a design science research methodology [23] to develop and evaluate an unobtrusive attention guidance functionality that is fully integrated into a new anchored discussion system. Drawing from the social constructivist model of learning, our design accomplishes two objectives: (1) promote students' task oriented reading of central domain principles from instructional materials; (2) support students' progressive improvement of tentative ideas focusing on central domain principles from instructional materials. We conducted an experiment to measure the success of our design and employed quantitative techniques to rigorously evaluate the utility of the developed attention guidance functionality.

The paper proceeds as follows. First, we propose a theoretical background, which provides a lens for understanding how we can facilitate unobtrusive attention guidance within collaborative learning situations. Second, we describe the design of a novel attention guidance functionality purposeful for our goal. Third, we present the research questions and methodology adopted to evaluate the utility of the developed attention guidance functionality. Fourth, we report the findings and draw conclusions.

2. Theoretical background

Collaborative learning includes many theoretical lenses to engage students in progressive improvement of ideas. Drawing from a social constructivist perspective, Stahl et al. [24] describe students as active constructors of knowledge who reflect on both their own and other group members' ideas. Under this perspective, we can view students' ideas as knowledge objects that can be shared, questioned, and negotiated through collaboration [25]. A crucial aspect of these collaborative activities is that they can move students from closed tacit understandings to open communal knowledge. In fact, the essence of social constructivism is that collaboration can promote conscious development of cohesive ideas that no single individual could have developed alone. Hence, deep learning in social constructivism depends on students' meaningful interactions with domain-specific content, peers, and context [26]. When AODs are truly collaborative, these interactions are intimately related and inform one another [27]. However, as pointed out by Dillenbourg [28], students do not always exhibit these interactions as expected. In other words, there is no guarantee that AODs will focus on progressive improvement of tentative ideas in the context of instructional materials' central domain principles. Accordingly, Scardamalia and Bereiter [29] stressed that "generating ideas appears to come naturally to people, especially children, but sustained effort to improve ideas does not" (p. 100).

Task-oriented reading in CSCL underscores students' ability to perform a reading task (e.g., read a scientific text that does not offer the visual aid of identifying key terms and principles) with a specific goal in mind (e.g., answer comprehension questions about central domain principles). This reading strategy highlights the fact that some information within a text relevant for a learning task is more important than others [30]. Consequently, students have to distinguish between relevant information by doing a back-and-forth reading between text and instructional task. A key feature of such back-and-forth activity is that students need to adjust their reading activity for a particular goal by re-reading relevant information and pausing to think about what they are reading [31]. In other words, students may not read a text linearly or passively, but dynamically and actively.

Research on reading comprehension shows that high levels of prior knowledge influences students' attention allocations in a text [32]. However, students new to a particular domain, where knowledge is often lacking, will have difficulty in allocating attention to relevant information in a text and monitoring their own comprehension. To compensate for this, prior research has demonstrated that students with low domain knowledge require some form of attention guidance, which helps them separate relevant from irrelevant information [e.g., 33, 34]. Thus, attention guidance can facilitate comprehension for students with relatively low domain knowledge and focus attention on more relevant rather than less relevant information from a text.

Reading comprehension involves the construction of meaning through interactions with the text [35]. As purported by Mayer [36], a student constructs meaning through the cognitive process of 1) selecting relevant information, 2) organizing selected information into a coherent representation, and 3) integrating a coherent representation with existing knowledge. This cognitive process underscores that selecting relevant information supports subsequent meaning construction activities by directing students' attention toward deep processing of relevant information in a text. In this regard, numerous studies on reading comprehension have found that guiding students' attention prompts them to mindfully interact with or reflect upon the relevant information in a text. For example, Lorch et al. [37] showed that attention guidance slows down students' reading times for text processing. As demonstrated by prior research, students can allocate this extra time to the detection and repair of coherence breaks in selected relevant information [38, 39], which in turn allows them to integrate a more coherent representation with their existing knowledge [40].

Applying a social constructivist perspective can enhance reading comprehension by allowing students to focus on relevant information as identified and analyzed by the entire group. Taking an "interactionist" approach [5] within Stahl's [41] collaborative knowledge building model, we can consider the above mentioned cognitive process as a prerequisite for articulating tacit pre-understandings, which provides a starting point for creating new meanings collaboratively. In order for this model of collaboration to be successful, it requires students to work collectively to review, edit, and verify articulated pre-understandings so that shared information can be organized to produce the best answer to a comprehension question [42]. In this way, collaborating students can use one another as a resource for learning and misunderstanding can be resolved. Therefore, we can consider that selecting relevant information from an instructional material is at the heart of students' collaborative learning which can influence their task oriented reading of central domain principles and, thus, their progressive development of tentative ideas focusing on those principles.

Within the context of individual reading comprehension, we view attention as the allocation of cognitive processing resources toward making sense of instructional materials' central domain principles [32, 42]. When applied to online learning conversations, we can define unobtrusive attention guidance as the use of visual cues to guide students' collaborative processing of instructional materials. After reviewing social constructivist literature on possible forms of guidance in general, we have identified two relevant forms of guidance that may effectively support students' collaborative learning processes.

One form of guidance, 'scaffolding' [43], is guidance initiated by an instructor, which fades when students become more proficient in knowledge construction. Prior research evaluating the utility of this guidance shows that it encourages students to openly acknowledge their common confusions, sparking topic-related questions among the entire group [19]. Thus, we can consider instructor guidance as the catalyst students need when addressing content they do not (fully) understand or agree with or that they otherwise may ignore. Prior research demonstrates that students do not always understand the reasons behind the importance of central domain principles suggested by their instructor and tend to end their discussion threads prematurely when the first plausible explanation surfaces instead of advancing and negotiating possible perspectives [19]. This is an important problem because under such conditions students can jump to conclusions, which are often inconsistent with the instructional materials' central domain principles [21].

The second form of guidance, peer-to-peer, is provided by the students themselves and allows students to become more active and responsible within the collaboration process. This form of guidance aims to support two learning mechanisms as noted by King (1998): monitoring peers' explanations of what they think are central domain principles and providing focused feedback on those explanations. Prior research evaluating the utility of this guidance shows that it supports negotiation of different perspectives in order to improve tentative ideas focusing on central domain principles [19]. However, interactivity graphs with this guidance technique indicate that such negotiations take time to cultivate because students are initially reluctant to critique or be critiqued for the fear of making mistakes [19].

In light of the above mentioned advantages and limitations, this study will combine both approaches to guidance in the design of an unobtrusive attention guidance functionality. The proposed design aims to better help students focus on the central domain principles from their instructional materials.

3. Artifact development

Design science research (DSR) is an important paradigm of IS research that aims to create new knowledge through construction and evaluation of IS artifacts [23]. The term artifact, as defined Gregor and Hevner [44], is a "thing that has, or can be transformed into, a material existence as an artificially made object" (p. 341). To meet the requirements derived from the theoretical background, we developed an unobtrusive attention guidance functionality integrated into a new anchored discussion system. The purpose of our new system is to promote students' meaningful interactions with content and peers within a context-based AOD. To achieve our purpose, our system first converts PDF-based instructional materials to a more flexible HTML format via the open source pdftohtml program. We then used the HTML formatted content as basis for the Marginalia, a browser independent open source Javascript program, to facilitate fine-grained annotation of shared content among students. Marginalia has two features that act as a catalyst for fostering the tight coupling between instructional material and related discussions. 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 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 pop-up sticky note that appears only when the cursor is on an annotated passage. Taken together, both features aim to promote context-based asynchronous discussions.

3.1. Attention guidance functionality

The main objective of our attention guidance functionality is to strategically, yet subtly, direct students' attention towards central domain principles of instructional material, while at the same time offering students an open learning environment in which they can choose their own topics and express their own ideas. One way to achieve this goal is to increase the font size of central domain principles. As demonstrated by De Koning et al. [45] 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. Figure 1 displays the user interface of the developed functionality.

This interface works by 1) a user (instructor or student) highlighting a passage, 2) clicking on the importance button on top of the instructional material, and 3) selecting a level of importance. Depending on the selected level of importance, the importance button 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. To begin with, the default font size represents a medium level importance. Next, the big font size represents a high level of importance determined by the individual. Finally, the bigger font size depicts consensus on collaboratively decided important themes. This visual contrast enables central concepts, principles, and their interrelations to become more noticeable and stand out against the rest of the text. We developed our attention guidance functionality in a manner that prevented the same user from marking a passage repeatedly and thus artificially inflating its importance. We took this approach to eliminate the risk of a single user biasing group's consensus on collaboratively decided important areas.

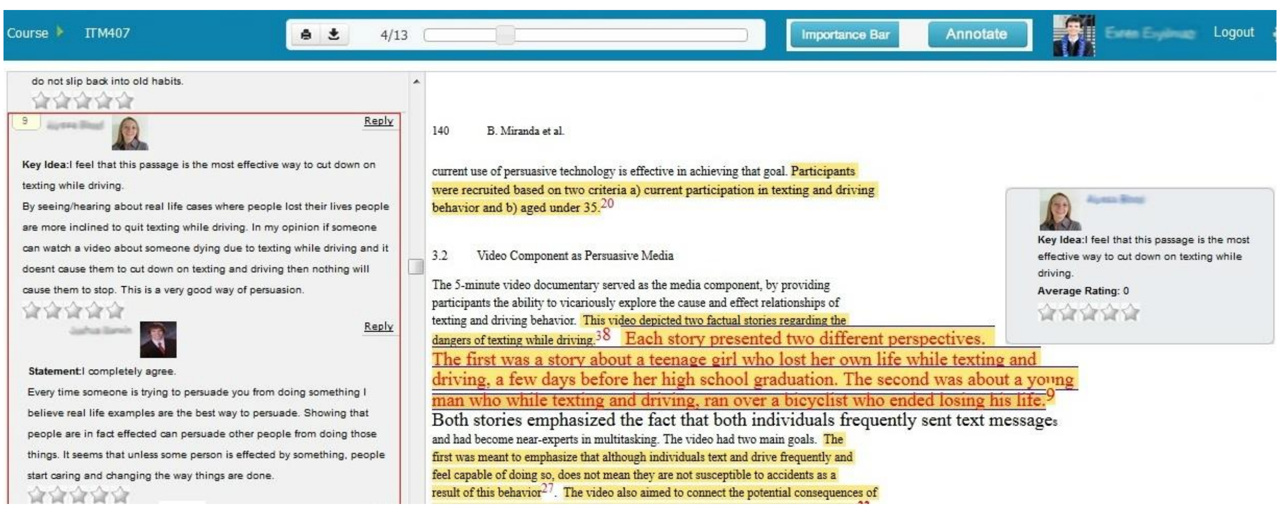

Figure 1. Attention guidance functionality

3.2. Control software

In order to isolate the effects of the attention guidance functionality presented above, we developed a control version of our new anchored discussion system void of our proposed changes. Figure 2 displays the user interface of the control software system

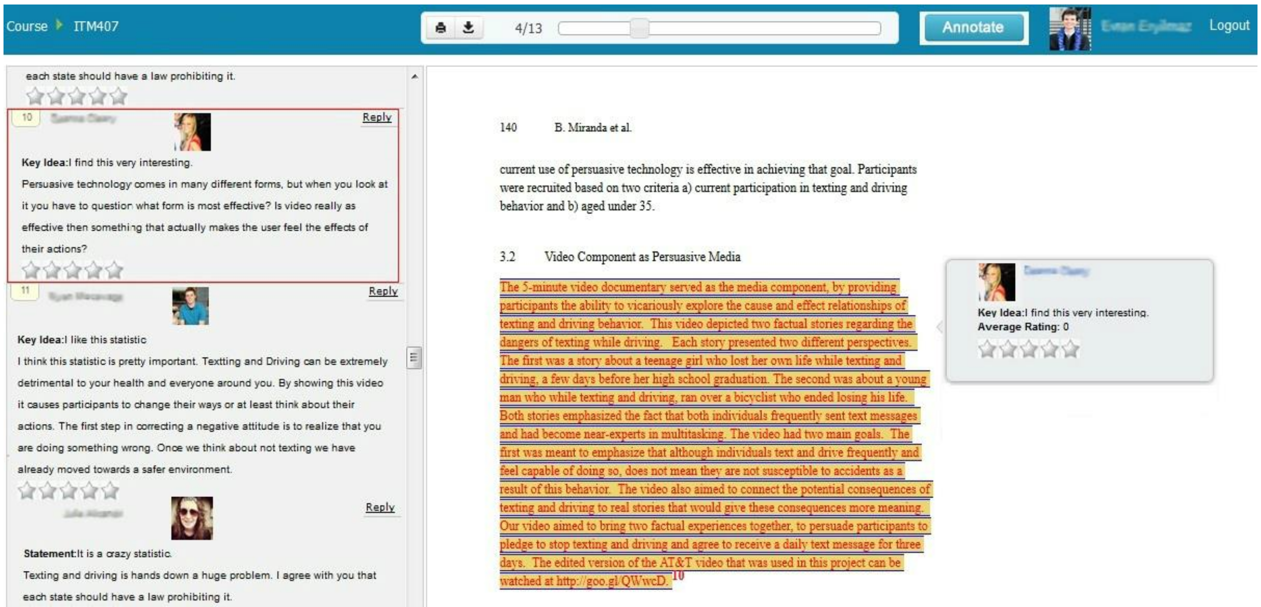

Figure 2. Control software

4. Research questions

Based on the theoretical background, we formulated two research questions to investigate the utility of the developed attention guidance functionality.

1. What are the effects of an attention guidance functionality in anchored discussion on:
   a. students' task oriented reading of central domain principles from instructional materials?
   b. students' online discussion message scores?
2. How do students' task oriented reading of central domain principles from instructional materials relate to their message scores in online discussions?

5. Methodology

To answer these research questions, we conducted an experimental study in two sections of a blended-format human-computer interaction course offered at a public university in the northeastern-United States. The goal of the course was to promote students' understanding of the fundamental principles for designing and evaluating interactive systems. The participants of the experiment were 64 undergraduate college students (33 males and 31 females) split across two sections of the same course. The mean age of the participants was 22.04 (*SD* = 1.36). Each section was set up identically and each contained 32 students. The same instructor taught both sections. We randomly assigned one section to the experimental group and the other to the control group. The experimental group had access to the attention guidance functionality, whereas the control group used the control software. Prior to the experiment, we provided training in a face-to-face class session to ensure that all students were able to work with the respective software system. Furthermore, we used this class session to teach students the structural components of an argument based on the Toulmin [46] argumentation framework in order to increase the quality of their online discussions. The instructional topic for the purpose of this experiment was persuasive technologies. This topic included two research papers, which we arranged in the following sequence. Paper 1 was "Creating Persuasive Technologies: an Eight-step Design Process"; and Paper 2 was "Examining the Efficacy of a Persuasive Technology Package in Reducing Texting and Driving Behavior." Each paper was covered during a two-week online discussion period. The learning task for both groups included two discussion activities. The first discussion activity asked students to annotate central concepts, principles, and their interrelations from these papers with their own underlying justifications. The second discussion activity asked students to collaboratively improve their tentative understanding of the papers' ideas. Participation in online discussions was compulsory and represented 10% of overall the course grade for the term.

The participants in both groups were required at minimum to annotate two passages per paper and respond to at least two fellow students' messages for that paper. The instructor's visual marks in the experimental group aimed to scaffold students' focused processing of central concepts, principles, and their interrelations. For example, what factors prevent a right audience from performing a target behavior? The design of the attention guidance functionality allowed the experimental group students to adjust the instructor's visual marks. In order to keep the conditions equal, we merely introduced and offered the attention guidance functionality to the experimental group without requiring them to make use of it. For the control group, except for providing the topics for discussion, the instructor was not involved in any way unless students asked for help.

5.1. Measurement of task oriented reading of central domain principles

We adopted the survey of reading strategies instrument developed by Sheorey and Mokhtari [47] to measure students' task oriented reading of central domain principles from instructional materials. To ensure validity, we pilot-tested the survey with a group of ten students who did not participate in the main study. Based on the feedback received from these students, the final form of the survey included the following items: (1) "I read slowly and carefully to make sure I understand what I am reading"; (2) "I try to get back on track when I lose concentration"; (3) "I adjust my reading speed according to what I am reading from an article"; (4) "When text becomes difficult, I re-read it to increase my understanding"; (5) "I stop from time to time and think about what I am reading". Students completed the survey by rating each item on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

5.2. Measurement of students' online discussion message scores

We employed Gunawardena et al.'s [48] content analysis instrument to assess students' online discussion message scores. This instrument enabled us to distinguish five different knowledge construction phases moving from "lower to higher mental functions" [48, p. 415]. The first phase, sharing information, represented statements of initial individual interpretations. The second phase, exploring dissonance, indicated identification of areas of disagreement among interpretations. The third phase, negotiating meaning, emphasized clarification of meanings to resolve disagreements. The fourth phase, testing proposed synthesis, delineated evaluation of a proposed synthesis against received facts. Finally, the fifth phase, agreeing on new knowledge, constituted summarization of agreement(s) in online discussion threads.

6. Results

We report our results in the order of our research questions. First, we examine the effects of attention guidance functionality in anchored discussion on students' task oriented reading of central domain principles from instructional materials and online discussion message scores. Second, we assess the relationship between students' task oriented reading of central domain principles from instructional materials and their message scores in online discussions.

6.1.Results of students' task oriented reading of central domain principles

To examine research question 1a, the effect on students' task oriented reading of central domain principles from instructional materials, a multivariate generalized linear model (GLM) was conducted with the group as a fixed factor and the five item scale of task oriented reading of the central domain principles as dependent variables. The results of the multivariate test were marginally significant, $F(5, 58) = 2.29$, $p = 0.057$, $\eta^2_{partial} = 0.165$. Univariate tests uncovered statistically significant differences between groups for each scale item, with exception of item 2 "I try to get back on track when I lose concentration", such that students in the experimental group reported higher scores than students in the control group (all ps < 0.032, all ds > 0.45) (see Table 1).

Table 1. Results from Univariate Test on Task Oriented Reading Scores

	Mean (*SD*)		Test Statistics	
Scale Item	Control	Experimental	*p* value	*d*
I read slowly and carefully to make sure I understand what I am reading	3.69 (0.54)	4.00 (0.57)	0.027	0.56
I try to get back on track when I lose concentration	3.84 (0.52)	4.09 (0.59)	0.075	0.45
I adjust my reading speed according to what I am reading from an article	3.69 (0.69)	4.06 (0.67)	0.031	0.54
When text becomes difficult, I re-read it to increase my understanding	3.81 (0.64)	4.19 (0.47)	0.010	0.68
I stop from time to time and think about what I am reading	3.72 (0.46)	4.03 (0.54)	0.015	0.62

6.2. Results of students' online discussion message scores

We recorded 252 messages (M = 7.88, SD = 0.49) posted by the students from the treatment group and 238 messages (M = 7.44, SD = 0.72) posted by students from the control group. In total, 64 students posted 490 messages. Two independent coders who were blind to the study's purpose were trained to use Gunawardena et al.'s [48] content analysis instrument with a random sample of 100 messages. After training, each coder independently coded all messages in the data set. The inter-coder Krippendorff's alpha reliability was 0.82, which exceeds 0.67 and indicates a satisfactory agreement beyond chance. All disagreements between coders were resolved by discussion after Krippendorff's alpha measurement.

To examine research question 1b, the effect on students' online discussion message scores, five message scores were created for each student based upon data from content analysis ratings. Message scores were computed as the proportion of students' posts in each message type. For example, if a student posted a total of 10 messages, and 2 of those posts were coded as sharing posts, the sharing message score for the participant was 2/10 or 0.20. Students in the experimental group had significantly higher exploring dissonance message scores, $t(62) = 3.97$, $p < 0.001$, $d = 0.98$ and negotiation meaning message scores, $t(62) = 2.82$, $p = 0.006$, $d = 0.71$ than students in the control group. Students in the control group had significantly larger sharing information message score than experimental group students, $t(62) = -3.81$, $p < 0.001$, $d = -0.85$. There were no statistically significant group differences in testing proposed synthesis message scores and agreeing on new knowledge message scores, $t(62) = .196$, $p = 0.845$, $d = 0.05$, and $t(62) = 3.63$, $p = 0.717$, $d = 0.09$, respectively.

6.3. Results of the relationship between students' task oriented reading of central domain principles from instructional material and online discussion message scores

To examine research question 2, the relationship between students' task oriented reading of central domain principles from instructional material and online discussion message scores, an aggregate score was computed from the reading strategies scale. This was justifiable because the scale demonstrated adequate internal consistency, $\alpha = 0.80$, $M = 3.91$, $SD = 0.44$. A hierarchical linear regression analysis was conducted predicting scores on the reading strategies scale. A step 1, group (0 = control, 1= experimental). At step 2, message scores were entered. At step 3, group by message score interaction terms were entered. The relationship between message scores and aggregate reading strategies scores did not vary significantly across groups, $F_{change(4,54)} = 0.42$, $p = 0.796$. Exploring dissonance message scores and negotiating meaning message scores were significant predictors of aggregate reading scores, $B = 2.77$, $t = 6.12$, $p < 0.001$ and $B = 1.08$, $t = 2.34$, $p = 0.023$, respectively. No other message scores were statistically significant predictors of aggregate reading strategy scores, all ps > 0.073.

7. Conclusion

Derived from the proposed theoretical background, we asked two original research questions to examine the utility of an unobtrusive attention guidance functionality integrated into a new anchored AOD system. Our dependent variables were students' task oriented reading of central domain principles from instructional materials and online discussion message scores. We will now summarize and interpret the three most important results of our study and then tie each result back to the theoretical background.

Regarding research question 1a, the effect on students' task oriented reading of central domain principles from instructional materials, analytical results show that attention guidance improved experimental group students' scores for each scale item, with the exception of item 2 ''I try to get back on track when I lose concentration". Given that reading comprehension requires construction of meaning through interacting with text [35], these results provide evidence that students within the experimental group expressed a concerted effort in these cognitive processes: selecting, organizing, and integrating instructional materials' central domain principles with their existing knowledge. This interpretation emphasizes that attention guidance prompted these students to reflect on and monitor their cognitive processes while reading information they deemed important instead of wasting time searching for new information.

In contrast, students' reading scores within the control group can be considered a symptom of difficulty for the focused processing of central domain principles necessary to understanding instructional materials. With respect to item 2, ''I try to get back on track when I lose concentration", we attribute the result at hand to the affordances of the annotation functionality for online reading [see 10 for a similar finding].

Regarding research question 1b, the effect on students' online discussion message scores, we found that the students within the control group produced new ideas much more than they attempted to refine existing ones (by either exploring dissonance or negotiating meaning). This finding resonates with Scardamalia and Bereiter's [29] remark that "generating ideas appears to come naturally to people, especially children, but sustained effort to improve ideas does not" (p. 100). Drawing on a social constructivist perspective, this finding offers a tangible representation that students within the experimental group tended to make a deliberate effort to take up each other's ideas in an effort to improve those ideas. A possible explanation for this finding is that the opportunities students have to express and share challenging concepts or important ideas directly serve as an invitation for building a learning environment of mutual understanding and negotiating meaning. In this vein, students' online discussion message scores within the control group represent a shallow processing of instructional materials' central domain principles which they did not (fully) understand or agree with. Moreover, consistent with prior research [49], we found that both groups did not differ significantly in testing proposed synthesis and agreeing on new knowledge message scores. A possible explanation for this finding is that students in both groups focused on individual acquisition of jointly constructed new knowledge after negotiating meanings.

Regarding research question 2, the relationship between students' task oriented reading of central domain principles from instructional materials and online discussion message scores, a hierarchical linear regression analysis demonstrated exploring dissonance message scores and negotiating meaning message scores as significant predictors of aggregate reading scores. From our theoretical lens, this finding emphasizes that engaging in higher levels of knowledge construction requires deeper reflection on instructional materials. Accordingly, we can consider such reflections engines that spark conceptual change in online discussions. Taking into account how AODs allow considerable time for reflection before responding [6], we can say that attention guidance prompted students within the experimental group to think more deeply about the relevance of instructional materials to their learning activities before participating in online discussions. To conclude, our study shows that attention guidance can act as a catalyst to fostering task oriented reading and progressive improvement of tentative ideas in online learning conversations. Based on these fruitful findings, we are currently investigating the effects of attention guidance on learning outcomes in order to design appropriate instructional activities and develop suitable teaching strategies that can improve students' learning in AODs.

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