The effects of students' asynchronous online discussions of conceptual errors on intentionally flawed teacher-constructed concept maps

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THE EFFECTS OF STUDENTS' ASYNCHRONOUS ONLINE DISCUSSIONS
OF CONCEPTUAL ERRORS ON INTENTIONALLY FLAWED
TEACHER-CONSTRUCTED CONCEPT MAPS

by

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A dissertation in partial fulfillment
of the requirements for the

Doctor of Philosophy Degree in Learning and Technology
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ABSTRACT

The Effects of Students’ Asynchronous Online Discussions of Conceptual Errors on Intentionally Flawed Teacher-Constructed Concept Maps

by

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Research shows that online discussions are often unfocused and without providing much benefit to students’ learning outcomes. One of the reasons behind this phenomenon is the lack of or inadequate scaffolding or guidance provided to students when participating on asynchronous discussion boards. The collaborative misconception mapping strategy is a tool that was designed to mediate cognitive and metacognitive processes via feedback provided by peers and a teacher-created concept map that contains intentional conceptual errors.

This study evaluated the effects of collaborative misconception mapping as compared with those of a traditional online discussion activity, where students post responses to discussion questions. Subjects were 52 undergraduate students in health sciences statistics classes at a large southwestern urban university; 24 in the misconception mapping group and 29 in the traditional discussion group. The level of meaningfulness of students’ discussions using a
rubric based on an intentional conceptual change model, and their post-test scores were compared. In addition, utilizing mean scores on the Metacognitive Self-regulation subscale of the Motivated Strategies for Learning Questionnaire (MSLQ), the collaborative misconception mapping strategy's effectiveness for students with low self-regulation skills was investigated. Findings indicate that the misconception mapping strategy outperforms the traditional discussion tool, as it provides a self-regulatory scaffold to students, and improves learning outcomes even for those with low levels of self-regulation. The strategy also enhances the meaningfulness of discussions in terms of their reflection of cognitive and metacognitive processes, and promotes more positive learner perceptions regarding the tool itself. It is recommended that instructors reevaluate their online discussion requirements, consider the negative impact unguided online discussions may have on their students' online learning experience, and provide appropriate cognitive and metacognitive scaffolding for optimal learning outcomes.
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CHAPTER 1

INTRODUCTION

Classroom activities are increasingly designed based on Lev Vygotsky's sociocultural theory contending that the development of individual cognition fundamentally relies on social interaction. Instructors attempt to create collaborative learning environments, which, according to some research, provide positive effects in face-to-face settings (Burnett, 1993), by requiring students to discuss concepts and ideas in small groups, or to complete final group projects collaborating with four or five peers. More recently, with the popularity of online classes and Internet-based tools, such as WebCampus, instructors often rely on asynchronous online discussions (online discussions) to provide similar learning environments in cyberspace. Many discussions are based on a discussion leader posting a 'reflection' regarding the course material, and other students responding to that post within a specified timeframe, without any initiating or guiding task or tool presented to them by the instructor. These discussions, however, tend to become unfocused, without much benefit to students' learning outcomes.

Instructors are often under the wrong impression that the mere act of partaking in online discussions will enhance students' knowledge of the content
at hand, without responsibility on the instructors' part past counting the number of
times students participate. This is evidenced by the fact that when searching
Google.com with the key words *enhancing online discussion*, typical tips to
instructors to increase student interaction and learning in online discussions
include "Require participation" or "Include a final grade for participation." The
State University of New York's Teaching, Learning and Technology webpage,
http://tlt.suny.edu/originaldocumentation/library/cm/enhancediscussion.htm,
which contains 14 such tips for instructors, is the first site that appears following
such a Google search. Although these tips are useful, they assume high levels of
cognitive and metacognitive strategies, such as organizing, planning, self-
monitoring, and self-regulation on the parts of the students, and they do not
address the need for instructors to design and use activities or tools to
encourage or prompt students to engage in *meaningful* discussions, that is, in
discussions that focus on the meaning of concepts covered in the course.

Simply requiring participation does not seem to support quality discussions or
help students create meaningful linkages between ideas in an organized way,
which means that discussions will most likely not foster better learning outcomes.
It is this author's view that if instructors, ignoring a crucial feature of sociocultural
learning promoted by Vygotsky, fail to provide scaffolding to facilitate meaningful
student discussions that are centered around the learning of course-related
concepts, then the pseudo social constructivist environment becomes a
detriment to students' attitudes and course-related performance. Thus, the
design, testing and dissemination of online strategies or scaffolds that promote
engaging interaction, metacognitive skills, and an increase in student learning is an important step in providing effective learning environments to the fast growing body of students, who opt to take online courses or must participate in online discussions as a requirement for face-to-face courses.

This study investigated the effects of a strategy, called collaborative misconception mapping, which was designed to mediate individual metacognitive skills, and enhance online discussions and students' learning outcomes. This strategy may best fit in with computer-supported collaborative learning (CSCL) as described by Stahl, Koschmann, and Suthers (2006). This collaborative concept mapping strategy is based on aspects of cognitive and metacognitive learning, a model of intentional conceptual change, as well as the Questioning the Author approach (Beck & McKeown, 2001), which will be discussed in the following chapter. It requires students in an online environment to systematically explain their corrections of conceptual errors they locate individually and collaboratively on an intentionally flawed teacher-constructed concept map, with help from their peers.

A concept map is a flow chart that generally consists of propositions, or statements about an object or an event, where nodes depict concepts and labeled lines symbolize relationships or connections among the concepts. Misconception maps differ in that some of the propositions within them contain common student misconceptions. It is these misconceptions that students are asked to find, correct and discuss on asynchronous discussion boards, where students post their initial map corrections with supporting evidence from their
course material or the Internet, and guide their partners in the location and explanation of further errors. Their discussions are structured by the misconception map itself to guide students through the intentional conceptual change process. Visual feedback from the concept map along with corrective feedback to and from peers allow for necessary scaffolding that encourages the surfacing of self-regulated learning, which can lead to elevated levels of connected understanding of concepts. In addition, the requirement to find and explain the rationale behind corrections of admitted conceptual errors on the concept map of the instructor’s knowledge promotes more meaningful discussions in the form of collaborative problem solving and scientific inquiry. Thus, collaborative misconception mapping offers an educational medium through which students’ cognitive and metacognitive processes are covertly being guided by an expert, allowing students to learn through individual and collaborative thinking.
CHAPTER 2

LITERATURE REVIEW

Online Discussions: Why They Fail
and How to Improve Them

Instructors frequently opt to require student participation in online discussions for both online and face-to-face university courses, as the activity is in line with the popular social constructivist views of learning. The rationale behind the use of online discussions or argumentations is the hypothesized positive impact of "confronting cognitions," or the mutual apprehension of "expressed statements, claims, [or] points of views" (p. 4) in computer-mediated collaborative environments (Andriessen, Baker, & Suthers, 2003). More specifically, that students' understanding deepens about the topic and its concepts at hand from the debate or discussion in which they engage. Although it is expected that students learn through their effort to realize shared understanding (Schwartz, 1999) and that discourse supports knowledge building (Bereiter, 2002), the process and outcome of online discussions are often fruitless (Hallett & Cummings, 1997; Heath, 1998).

Research shows that online discussions are frequently shallow and meaningless (Andriessen, Baker & Suthers, 2003; Nussbaum, 2005) partially due
to the fact that students often engage in these discussions at minimal levels (Hara, Bonk, & Angeli, 1998; Wickstrom, 2003). Such discussions are characterized by low participation rates, inadequate collaboration as well as low levels of learning and learner satisfaction (Hallett & Cummings, 1997; Kreijns, Kirschner, & Jochems, 2002). According to Nussbaum (2005), students "simply repeat points that other classmates have made rather than adding to a discussion through disagreeing, framing counterarguments, or providing examples" (p. 292). Some of the reasons for such negative processes and outcomes associated with online discussions may include the threaded format itself, inhibiting student characteristics, lack of appropriate instructor scaffolding and inappropriate placement of conflict between students rather than within students. A discussion of these possible connections follows.

The Threaded Format

The typical discussion online includes a main posting, a linked response, then alternating responses from students with the same subject heading repeating. Chen and Hung (2002) venture to suggest that this traditional threaded discussion format may not be appropriate for true knowledge building because students fail to internalize the “collective knowledge” gathered in the discussions. As Andriessen and colleagues (2003) point out, threaded discussions are “notorious for their lack of convergence,” (p. 13) partially due to the fact that their representations do not generally reflect the conceptual content of the discussions, but rather just the historical record of responses. Researchers evaluating computer-based discourse often conclude that students’ arguments
are superficial and discussion threads are unfocused (Andriessen et al., 2003). This may be so because some arguments may not be linear (Adam, 1992; Coirier, Andriessen & Chanquoy, 1999), contrary to what threaded discussion boards assume. Coirier and colleagues compare a straight road from point A to point B and a trip full of U-turns and short-cuts, to illustrate the difference between linear and non-linear arguments. Regardless of the level of desire students possess to collaborate and learn, if the discussions are unstructured and unorganized, the learning process may be impeded by frustration associated with the sifting through the maze of endless postings, whose subject headings may not even indicate the respective content areas.

**Inhibiting Student Characteristics**

In addition to the actual threaded format, some studies have investigated the negative effects of some affective student characteristics on online discussion related behavior (Nussbaum, Hartley, Sinatra, Reynolds, and Bendixen, 2004; Sonnenwald & Li, 2003). For example, willingness to disagree with peers can relate to levels of anxiety and extraversion (Nussbaum et al., 2004), which influence one’s level of participation in online argumentation. Students with certain personalities or traits, such as introversion or high anxiety levels, may not benefit from or add to the knowledge building web of online discussions. Similarly, students’ differing attitudes toward working in peer-oriented environments can have a bearing on the success of online collaborative activities.
Some studies investigating the relationship between academic achievement and preference for cooperative versus individualistic learning activities indicate that academic achievement is often predicted by individualistic preferences (van-Voorhis, 1991; Emanuel & Potter, 1992). In other words, students who prefer to work alone might perform better. In addition, students with strong individualistic learning preferences reported a more negative perception toward an activity requiring online collaboration than toward one requiring face-to-face collaboration (Sonnenwald & Li, 2003). These student characteristics may have some influences on students' performance in online discussions, thus it is important to assess students' cognitive and affective tendencies (Hartley & Bendixen, 2001), as well as their effects on learning outcomes, and adjust online course design and activities accordingly. It is possible that social constructivism is not conducive to all students' learning, and that it may actually be detrimental in not only leading to pointless discussions, but also lower levels of engagement with the material at hand due to frustration. On the other hand, students with individualistic learning preferences may benefit from online discussions if these discussions are planned and structured appropriately, and the instructor conveys its benefits to all students.

Lack of Appropriate Scaffolding

Kreijns and colleagues (2002) hypothesized that one of the main reasons behind unsuccessful online discussions is instructors' "assumption that [effective] social interaction can be taken for granted and it will automatically happen" (p. 10) without any intervention from instructors. Instructors are often mistaken that
as long as they make participation in discussions, online or face to face, a class requirement that is worth a portion of students' grades, they are enhancing student learning. There is some evidence to the contrary: for example, Chen (2002) found that students who studied more with their peers in computer laboratory environments earned lower grades; and a study conducted by Rittschof and Griffin (2001) indicates that reciprocal peer tutoring did not improve students' understanding of course material compared to an individualized study task. The quality of students' discussions closely relates with the characteristics of the instructional task in which they participate (Kumpulainen, 1996), and the nature of the tasks has an effect on the type and amount of processing, which consequently affect learning outcomes (Cohen, 1994; O'Donnell & Dansereau, 1992). It seems that if peer interactions, whether face-to-face or on-line, are without appropriate scaffolding, subsequent learning outcomes will clearly suffer.

Providing scaffolding for effective student discussions does not mean that instructors have to interact with students on the discussion boards, which some researchers advise against because it might prevent students from constructing their own knowledge (Burstall, 2000; Li, 2003; Mazzolini & Maddison, 2003). What it means is that instructors must facilitate effective online discussions (Blignaut & Trollip, 2003; Figallo, 1998; Knowlton & Knowlton, 2001; Love, 2002; Moller, 1998). Some general recommendations regarding such facilitation include providing a topic that contains controversial issues (Blignaut & Trollip, 2003; Burstall, 2000) or provocative (Love, 2002) introductory questions that promote higher level thinking (Savage, 1998). Even with such strategies, however, Hara
et al. (1998) documented that student participation a second time in an online discussion thread is rare, indicating low levels of engagement and processing. It follows that it is crucial to design and implement interventions that facilitate effective student discussions (Andriessen, et al., 2003) in order to achieve desired learning outcomes.

*Examples of scaffolding tools to enhance online discussions.*

Research shows that certain specific instructional methods and tools can enhance online discussions and make them more meaningful to students by engaging them in exploratory talk (Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2004; Veerman, 2000), defined as constructive criticism of each other's ideas, where students provide justifications and alternatives in order to achieve joint agreement (Mercer, 1995). Nussbaum (2005) tested the effects of goal instruction on interactive argumentation, and found that adding statements, such as "try to persuade others of your point of view" or "provide as many reasons as you can to justify your position" resulted in deeper arguments. Nussbaum and colleagues (2004) tested the effects of note starters, a menu of phrases, such as "on the opposite side," "my argument is," one of which students can select when typing a response. They found that the frequency of disagreements was higher when note starters were used, especially for students of low curiosity and low anxiety levels, indicating heightened levels of exploratory talk. In these studies, however, students were faced with issues that likely create disagreement due to the provocative nature of the questions, such as "should
teachers grade on grammar or just content," and "does television watching cause children to be violent."

On the other hand, a study with the CLARE system (Wan & Johnson, 1994), for example, where software engineering students critiqued each other’s writing by using “specific sentence openers,” found that the “restricted input mechanisms can actually inhibit elaboration” (Veerman, 2000, p. 59). It is possible that the software engineering students shied away from discussing because they just did not find many things that would prompt them to disagree, due to the technical nature of the topic at hand. Many educational topics might be technical in nature, especially in mathematics or the sciences, which might necessitate the design of new strategies that encourage discussion among students in these areas of study. More of these strategies or tools, such as Betty’s Brain or the Belvédère system, which rely on concept mapping or diagramming activities, will be described in a subsequent section of this chapter that discusses concept mapping in computer-supported collaborative learning environments. First, however, the discussion of why online discussions fail continues.

The Role of Disagreeing, Critiquing, and Conflict

Students also often choose not to disagree with each other in online discussions because, as Veerman (2000) theorizes, students’ perception is that written material is more infallible than spoken words, which makes them become less critical of information and possible problem solutions presented to them by other students online than in face-to-face settings. According to Mason (1992), students do read and accept facts that are in print because they perceive written
material to be finalized and certain, thus neglecting to process text ideas on higher than memorization levels. Beck and McKeown (2001) observed this student behavior and designed a system in an attempt to help facilitate text comprehension by engaging students with the text content and discussions with each other. The Questioning the Author approach involves hypothetical “dialogues with the text’s author,” who is considered “fallible” in that the printed material simply contains his or her ideas written down, which “may not be clear or complete” (p. 229). Students who used this technique by analyzing the author’s intent and meaning of his or her statement became much more active in classroom discussions: they were more likely to initiate questions and comments, display agreements and disagreements, and show better recall as well as monitoring of their levels of comprehension of the text at hand. These positive effects attributed to this innovative new way of reading text would suggest that it is the process of collaborative critiquing admittedly fallible material that might contribute to more meaningful discussions and increased learning and use of cognitive and metacognitive strategies, rather than disagreeing with each other.

Most instructors, however, view disagreements among students on the discussion boards as meaningful postings, not realizing that this expectation itself may prevent students from contributing invaluable responses. After all, as Andriessen and colleagues (2003) pointed out, “the more [students] go deeper into cognitive disagreement, the greater the threat to their interpersonal relationship” (p. 17). The elimination of this threat is an important step toward the optimization of student discussions because student discussions can otherwise
be negatively influenced by students’ personal characteristics, such as “politeness strategies” (Veerman, 2000) or levels of anxiety (Nussbaum et al., 2004).

Koschmann (2003) agrees that the wrong kind of argumentation is generally being fostered in instructional settings. In the area of mathematics, for example, it is recommended that discussions foster metacognitive and cognitive activities, such as the formulation or clarification of ideas (Lampert & Cobb, 2003). Brown and Palincsar (1989) suggest that the role of conflict, rather than disagreement, is central for the "generation of explanation, justifications, reflection and a search for new information" (p. 311), which is a process necessary for learning material in the area of science. In other words, in science learning, rather than rejecting what others have said, it is the recognition of problems [or inconsistencies], formulation of questions and co-construction of explanations that result in better learning outcomes (Alexopoulou & Driver, 1996; Chan, 2001). Thus argumentation does not have to be based on “social conflict” to initiate stimulus for learning (Koschmann, 2003), but on social or “collaborative conflict-resolution.” Likewise, online discussions related to scientific concepts should not have to be disputational; instead, they should involve students in discourse and co-discovery through a type of exploratory talk, which does not necessarily focus on students’ critique of each other, but rather on their critique of an external source or solution of a common problem.

This author suggests that constructive interaction should be dialog that resolves inner conflict rather than the kind of “dialog that promotes conflict,” as
recommended by Koschmann (2003, p. 263). After all, it is individual conflict that is the "driving force of knowledge transition, not interpersonal disagreement" (Andriessen et al., 2003, p. 13). Savery and Duffy (1996) agree that cognitive conflict or puzzlement induces learning and shapes the organization of what is learned. Disagreement, then, should not be the focus of the dialog; a conflict should precede the dialog to provide an opportunity for students to collaboratively solve a puzzle through their discussions. Such constructive student interaction prompted by "conflict" within students might increase the quality of online discussions, as well as learning outcomes associated with student discussions regarding scientific concepts. Examples of collaborative conflict resolution activities that may enhance student discussions and better learning outcomes include solving partially defined problems in groups (Erkens, 1997) or participating in collaborative writing projects (Burnett, 1993). Such meaning-making activities may be supported by technology, under the umbrella of computer-supported collaborative learning (CSCL) (Koschmann, 2003), which will be further discussed in the following sections, with special emphasis on strategies which make use of concept mapping activities. This will be preceded by a discussion of the importance of utilizing instructional tools or strategies that promote metacognitive and cognitive processes, and how concept mapping activities can contribute to accomplishing such a goal.
Online Discussions to Promote Necessary Cognitive and Metacognitive Processes

Although inner conflict, or cognitive dissonance (Festinger, 1957) has been known to create a drive for resolution, it alone may not be enough to prompt individuals to adequately engage with the material, participate in meaningful discussions, and initiate conceptual change (Sinatra & Pintrich, 2003). Hatano and Inagaki (2003) suggest that conceptual change is induced socioculturally, more specifically, through comprehension activities with the support from peers and led by the teacher. Bereiter and Scardamalia (1989) suggest that intentional learning is not often promoted by school activities (p. 366). For online discussions to become this intentional-conceptual-change-inducing sociocultural environment, they must be structured to prompt such change. The process of intentional conceptual change, which can be defined as change or learning "initiated and/or controlled by the learner's intentional cognitive or motivational process" (Sinatra & Pintrich, 2003, p. 7), involves the following student actions:

1. becoming aware of students' own existing knowledge,
2. responding to a piece of inconsistent data that leads to dissatisfaction with the existing conception,
3. having deliberate goal orientation to learn the material to compare rival conceptions,
4. attempting to solve the puzzles through high engagement, such as questioning or discussions, to compare rival conceptions,
5. weighing the plausibility of misconceptions,
6. and engaging in critical reflection by engaging thoughtfully with ideas (Sinatra & Pintrich, 2003).

This process is supposed to place the “impetus for change” within the learner’s control (Sinatra & Pintrich, 2003, p. 2) by involving students’ metacognitive skills and affective predispositions. Intentional conceptual change, however, rarely happens as students often lack the necessary cognitive and metacognitive skills, such as monitoring and goal seeking (Sinatra & Pintrich, 2003).

One of these monitoring skills is self-regulation, which is "the degree that individuals are metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 1994, p. 3). Self-regulation is an invaluable metacognitive skill students must possess for successful learning and transfer in any learning environment (Theodorou & Meyer, 2001). Randi and Corno (2000) suggest that "self-regulated learners seek to accomplish their [learning] goals strategically" (p. 651). As Stright and Supplee (2002) pointed out, through their instructions teachers must promote self-regulatory behaviors, such as help seeking, attention to instruction, self-monitoring of cognitive effort, and self-evaluation of progress and performance. This is especially important in an online environment, where students must be more independent and motivated to read, process and participate without personal instructor supervision.

Randi and Corno (2000) outline some features of instruction that provide opportunities for self-regulated learning, such as student collaboration, explicit strategy instruction, diagnostic performance evaluation, and curriculum-
embedded assessment. While Randi and Corno (2000) seem to focus on external instructional features that guide student behavior thus changing their internal characteristics to foster deeper learning, Travers and Sheckley (2000) suggest practices that enhance self-regulatory behavior “from the inside out”. They encourage teachers to (1) guide students' self-beliefs, goal setting and expectations, (2) promote reflective dialogue, (3) provide corrective feedback and strategy modeling, (4) connect abstract concepts and (5) link new experiences to prior knowledge.

It is this author's view also that educators should be the ones in control of guiding students on the path of intentional conceptual change by scaffolding their metacognitive and cognitive actions at each step of the process. This is not to say that direct instruction is necessary. Rather, specific covert or implicit prompts in the instructional design can help maximize learning by virtue of mimicking cognitive or metacognitive processes, such as the process of intentional conceptual change, while initiating or supplementing self-regulated learning. This would prevent novices from being overwhelmed by the levels of cognitive activities required by typical unguided or minimally guided learning environments as described by Kirschner, Sweller and Clark (2006). The description of Collaborative Misconception Mapping (CMM), a strategy that promises to offer such metacognitive and cognitive prompts in a constructivist setting, will follow later in this chapter. First however, as this strategy is centered around concept mapping, the idea of concept maps as instructional tools that foster cognitive and metacognitive processes is addressed.
Concept Maps to Improve Discussions, Organization and Monitoring Skills, as well as Learning Outcomes

Mayer (1999) asserts that meaningful learning involves active cognitive processing in which learners organize relevant information into a coherent representation, and “make connections between visual and verbal representations and prior knowledge” (p. 613). Concept maps, which have been defined as "tools for organizing and representing knowledge" (Novak, 2003, p. 1), enhance constructive and meaningful learning by providing visual feedback to students about the structural representation of their knowledge (McClure, Sonak, & Suen, 1999). Concept maps, then, are basically visual representations of an individual’s knowledge, framed in a unique structure. Some venture to say that concept maps are indeed representations of one’s structural knowledge. This author, however, suggests that it may be more appropriate to assume that concept maps help structure one’s knowledge on a tangible medium for ease of communication. Drawing a map that fully and accurately reflects one’s knowledge, much like writing an essay that does the same, is a painstaking process and often not even attainable.

The educational benefits of studying with the help of concept maps as graphic organizers, as well as drawing concept maps of a topic to foster metacognitive awareness, have been the focus of investigations by researchers for decades. For example, concept maps as graphic organizers can make content explicit, which is especially important in the area of science where students might display “fragmentary understanding of a topic and are frequently unable to integrate all
the components to form a meaningful overview" (Kinchin & Hay, 2000, p. 45).
Concept maps, when constructed from scratch by students, with their visual
representations that help students monitor their “conceptual state” may actually
aid the self-regulation process, potentially leading to higher levels of learning
(Theodorou & Meyer, 2001) or conceptual change. Such concept maps can
provide visual, as well as textual feedback to students about the preexisting
structural representation of their knowledge and potentially clarify misconceptions
(McClure et al., 1999). Concept maps as metacognitive monitoring tools have
been shown to assist in knowledge construction, and the identification of
misconceptions and the monitoring of conceptual change (Gravett & Swart,
1997).

Some studies show that interacting with partially completed teacher-
constructed maps might have even more beneficial effects on student learning
than constructing maps from scratch (Tan, 2000; Chan, Sung, & Chen, 2001).
Filling in missing concepts or relationships on a teacher-constructed map, for
example, can lead to better learning outcomes (Chan et al., 2001). In their study,
Chan and colleagues found that when junior high school biology students
received an incomplete expert map that they were to complete (construct-on-
scaffold) on the computer, they outperformed students who constructed maps
from scratch, relying merely on a list of concepts and relationships. In another
study, Chang, Chen and Sung (2002) discovered that if the concept map
contained errors that students were to correct, they received higher scores on
text comprehension and summarization post-test than those who used the construct-on-scaffold activity.

Some researchers also identified the possible benefits of combining concept mapping or diagramming activities and collaborative environments (Veerman, 2000; van Boxtel, van der Linden, Roelofs and Erkens, 2002). The Belvédère system, for example, provides students the platform where they can discuss conflicting claims electronically with the construction of diagrams. Students can add text into the diagrams by using a predefined set of boxes, such as “hypothesis”, “data”, “unspecified;” and links, such as “for”, “against” or “and” (Veerman, 2000). Such graphical representation may foster comprehension by pointing out salient and important features of the content at hand (Gyselinck & Tardieu, 1999; Reimann, 1999). A study of the Belvédère system shows that producing argument maps or argumentative diagrams can increase concept-focused argumentation while balancing positively and negatively oriented arguments (Veerman, 2000). Non-linear representations, such as argumentation maps might better facilitate non-linear though-patterns and ultimately, learning. Suthers (2003) agrees that external representations, such as graphs, serve important roles when a group is “constructing and manipulating shared representations as part of a constructive strategy,” namely, “initiating negotiations of meaning” and “providing a foundation for implicitly shared awareness” (p. 31). Although these tools help structure student interaction, which can lead to an increase in task-oriented behavior (Baker & Lund, 1997), they do not necessarily provoke discussion (Veerman, 2000).
van Boxtel, van der Linden, Roelofs and Erkens (2002) found that, rather than simply structuring the discussions with the use of diagrams, it is students’ co-construction of concept maps that can be successful in "provoking and supporting a student discourse that contributes to the approximation of [...] concepts" (van Boxtel, et al., 2002, p. 40). The strategy evaluated by van Boxtel and colleagues (2002) involved secondary physics student pairs constructing concept maps from scratch, relying on material they had read by themselves and a list of concepts provided to them by the researchers. In the authors' view, "the [concept mapping strategy] ... serves as a visible representation that can facilitate communication about abstract concepts and relationships" (van Boxtel, et al., p. 43). However, despite resultant course-material-relevant student discussions and significant learning gains, this concept mapping strategy did not prompt explanations of relationships and descriptions of phenomena, and some of the most frequent misconceptions did not emerge for discussion among students. While van Boxtel and colleagues (2002) identified the possible benefits of combining concept mapping activities and collaborative environments, Veerman (2000) suggests that it is critical engagement “combined with production of a joint solution” that might stimulate engagement in more meaningful argumentative discussions (p. 59).

Discussing misconceptions on student-created concept maps is one such collaborative strategy. The *Betty’s Brain* software (Biswa, Schwartz, & Bransford, 2001), is a tool that facilitates students’ discussion and recognition of their own and their peers’ faulty conceptions depicted on student-created concept maps.
maps. This computer application helps students create computerized concept maps, which become a teachable agent's web of knowledge of a specific topic. Using the nodes and connections constructed and organized by the students, Betty, a computerized teachable agent, verbally answers questions, and her answers are then discussed by students in groups. The discussion of Betty's answers not only allows for the indirect testing of students' hypotheses but also the clarification of their misconceptions. In this author's view, this software also enables students to objectively discover and discuss where Betty's newly created knowledge, which is really their own knowledge, falls short, by actually "displacing" their own misconceptions onto Betty's "brain." This innovative tool, with its "displaced error source" characteristic, might decrease students' inhibition to freely discuss areas of inconsistent conceptions or misconceptions, because students only indirectly address flaws in their own and their peers' thinking. In addition, the concept mapping feature of Betty's Brain also promotes metacognitive processes by providing a visual representation of students' levels of knowledge and understanding (Novak, 2003). This strategy, however, requires computer programming that most instructors cannot be expected to perform.

**Collaborative Misconception Mapping**

Borrowing from the apparent design benefits of concept mapping activities described in this chapter, and subsequent to pilot studies testing different combinations of such activities, this author designed the *collaborative misconception mapping* strategy. A description of this strategy and the theory behind its design follows. In a *collaborative misconception mapping* activity,
students receive teacher-constructed complete concept maps that contain conceptual errors based on common student misconceptions (for an example of such a concept map, see Figure 1). Some areas of the concept map, either the nodes or the links, contain intentional conceptual flaws. The students' task is to 1) find errors, 2) report them to their online discussion partners, 3) provide supporting evidence regarding their justifications and corrections, using their handouts, books or relevant websites, 4) and carry on a discussion until all misconceptions are found and corrected. This author has tested the effects of construct from scratch and construct-on-scaffold concept maps and found that students became frustrated due to the long lists of concepts and relationships they had to sift through to fill in the missing bubbles or links on a concept map. A fully constructed teacher-created concept map eliminates this frustration associated with fill-in-the-blank and construct from scratch concept mapping activities, while providing a platform for students to participate in the process of scientific inquiry of critiquing, searching, explaining and justifying information through the production of a joint solution. Similarly to the Betty's Brain concept mapping activity, this strategy requires students to collaboratively identify and explain conceptual errors in, however, by using a teacher-constructed map with planted misconceptions, it promises to provide a more planned and structured process. This is so, because the teacher-constructed map would include typical student misconceptions phrased in a clear manner, while student-constructed maps may depict random and possibly over-simplified statements that may even
be grammatically flawed, making it possibly difficult to discuss actual concepts at hand.

Before discussing the theory behind misconception maps, it is important to define misconceptions. Typical misconceptions can be defined as student knowledge that is inconsistent with the commonly-accepted scientific thought (Cho, Kahle, & Nordland; 1985). Teachers can log common student misconception and create conflict maps (Tsai, 2000), which are simple concept maps that indicate, among other factors, students' alternative conception and the accurate scientific conception. According to Tsai (2000) these conflict maps "could help students seek a stable and desirable equilibrium between the conceptual schema they have already assembled and the perceptual information arising from the environment" (p. 300). Hameed, Hackling, & Granett (1993) agree that explicitly addressing misconceptions is critical, or else instruction may not have any effect on the learning of correct concepts.

While pointing out students' misconceptions and the correct conceptions is necessary, students may benefit more from participating in a knowledge building strategy (Bereiter, 2002) centered around finding and correcting common misconceptions by providing supporting evidence from course material. In this strategy, students build a "cognitive artifact," or a collection of ideas and thoughts, through the processes of scientific engagement promoted by Alexopoulou and Driver (1996), Brown and Palincsar (1989), Chan (2001) and Lampert and Cobb (2003). Scientific engagement may be defined as, the formulation or clarification of ideas, justifications, reflections and search for new
information, and recognition of inconsistencies, formulation of questions and co-construction of explanations. In Bereiter's view, discussion threads can become this artifact, reflecting the processes of learning; similarly, students' online collaborative correction of concepts on a concept map may provide such outcomes.

Theoretical framework for misconception mapping.

The preceding review of literature indicates the following: cognitive and metacognitive skills are crucial for optimal student learning; discourse among students must be appropriately scaffolded to enhance levels of cognitive and metacognitive skills as well as learning, by providing meaningful awareness of one's knowledge levels; concept mapping activities can enhance discourse among students, as well as their cognitive and metacognitive processes, such as organization and monitoring, and they also have a positive affect on the learning outcome; critiquing an external source can lead to more meaningful discussions; typical misconceptions should be explicitly addressed by educators for optimal learning outcomes. In addition, in the area of mathematics and sciences it is recommended that discussions foster formulation or clarification of ideas (Lampert & Cobb, 2003); justifications, reflections and search for new information (Brown & Palincsar, 1989) as well as recognition of problems [or inconsistencies], formulation of questions and co-construction of explanations (Alexopoulou & Driver, 1996; Chan, 2001). The design of collaborative misconception mapping draws from these findings. This strategy is hypothesized to promote cognitive and metacognitive student actions, enhance the
meaningfulness of discussions, and ultimately improve learning outcomes. This collaborative concept mapping strategy embraces the importance of cognitive and metacognitive skills, theories of self-regulation as well as the Questioning the Author approach (Beck & McKeown, 2001), to promote scientific inquiry through concept organization, planning, monitoring and regulated learning, while mimicking the intentional conceptual change process during online discussions.

The strategy was designed as a scaffold to enhance online discussions and make them more meaningful to students by engaging them in exploratory talk (Nussbaum et al., 2004; Veerman, 2000), characterized by collaborative criticism of ideas, where students' provide justifications and alternatives in order to achieve joint agreement (Mercer, 1995). Students must provide explanations about their stand on what is incorrect in the map, which in knowledge-building discourses is considered the main constructive strategy (Scardamalia & Bereiter, 1994; p. 274). The requirement to collectively explain and critique the rationale behind corrections of admitted conceptual errors on a concept map of the instructor's knowledge, promotes more meaningful non-defensive discussions in the form of collaborative problem solving. Collaborative misconception mapping may best be characterized as Computer-Supported Collaborative Learning (CSCL) whose goal is to “create artifacts, activities and environment, that enhance the practices of group meaning making” (Stahl et al., 2006, p. 9). It serves as a medium to structure students' responses and allow for more coherence and convergence necessary for effective discussions, according to recommendations of some proponents of CSCL (Andriessen et al., 2003).
In addition to help structure discussions, collaborative misconception mapping was also designed to aid the metacognitive processes of students with low levels of self-regulation. While Randi and Corno (2000) suggested that explicit self-regulation strategy instruction is a crucial step in achieving optimal levels of self-regulation for students, it may be also possible to structure a learning strategy to implicitly mediate and maintain self-regulatory behavior (Stright and Supplee, 2002). In collaborative misconception mapping, discussions are structured by the misconception map itself to mimic and promote the steps of the intentional conceptual change process, thus heightened levels of self-regulation and ultimately more meaningful content related exploratory talk, and conception change. Although students' self-regulation levels may not increase per se, the tools and scaffolds of the strategy promise to give support to students with low self-regulation levels through steps of the learning process that would potentially become obstacles otherwise. One might use the analogy of stepping stones in the river of learning, which keep low self-regulators out of murky water.

The following is a description of how the teacher-initiated peer-guided collaborative misconception mapping strategy mimics the conceptual change process by supporting self-regulating behavior, while prompting collaborative scientific reflection. The strategy prompts students to:

1. have deliberate goal orientation to find the misconceptions and their corrections via search for new information in instructional material;
2. become aware of students' own existing knowledge through discovery or lack of discovery of misconceptions;
3. respond to inconsistent data, in the form of located misconceptions on the map, that leads to the questioning of existing conception and searching for supporting evidence;

4. collaboratively weigh the plausibility of misconceptions while trying to provide explanations to correct conceptions;

5. attempt to individually and collaboratively solve the misconceptions on the map while comparing rival conceptions through high engagement, such as questioning, discussions, help-seeking and hint providing;

6. provide and receive critical reflection by collaboratively engaging thoughtfully with ideas throughout the entire process;

7. provide and receive feedback in the form of hints or pinpointing of concept confusion throughout the entire process.

As can be seen in Figure 2, in addition to the steps described by Sinatra and Pintrich (2002), the strategy adds a feedback function. More specifically, it provides continuous visual feedback from the concept map, which, along with corrective feedback from peers, further promotes opportunities for knowledge monitoring, and might ultimately lead to elevated levels of connected understanding of concepts. The feedback function has been added to the process because it is possible for students to be “aware” of their knowledge and be under the impression that their knowledge is in line with correct conceptions, when in reality they have misunderstood the concepts at hand. Without outside guidance, students may over- or under-estimate their knowledge levels. Students’ monitoring of their levels of knowledge by themselves, without
feedback from the instructor or other peers, can be similar to looking into a muddy rear-view mirror before changing lanes on a highway – the nearby cars' honking (feedback) might be the only cue to reevaluate one's action.

**Description of the Collaborative Misconception Mapping Strategy**

Because individual preparation prior to group discussions tends to create better quality argumentation and learning results (Bull & Broady, 1997; van Boxtel, van der Linden, & Kanselaar, 2000), students are asked to individually review the flawed concept maps and course material in an attempt to identify and correct intentional errors on the map. Based on theories and findings from Beck and McKeown (2001) on the Questioning the Author approach, it was the author's hypothesis that questioning the content on an externalized representation of the instructor's knowledge, students would likely become more engaged in the course material they have to read in order to correct the errors as well as in the subsequent online discussions regarding their observations. Misconception maps then, can serve as the fallible authority and virtual tutoring medium that can "signal misconceptions" while "making abstract situations concrete" (Veerman, 2000), thus fostering better metacognitive processes.

Once students attempt to resolve some of the cognitive dissonance (Festinger, 1957) within themselves prompted by the inconsistency between their cognition and the errors on the concept map, students participate on "dyad discussion boards," where their task is to report to their partners what they think are errors and why. Partners receive maps with differing errors to prevent students from simply listing, correcting and explaining all the errors leaving the
other students with no other task but to agree. Each student's map, however, indicates the area where the student's partner's errors are, which allows students to send hints to each other regarding the location or the correction of their partners' errors. This also allows for help-seeking behavior, which according to Stright and Supplee (2002) is important for self-regulated learning. Together the dyads can continue to explore the map to verify and find all errors, compared to non-errors on the partner's map, while they are asked to back-up their claims with examples and/or proof from course material or from the Internet. This strategy provides opportunities for diagnostic performance evaluation by peers, as recommended by Randi and Corno (2000), to optimize students' self-regulation. Once students locate all errors on their maps, they have access to a corrected map, which provides corrective feedback as suggested by Travers and Sheckley (2000) for the further enhancement of their self-regulatory behavior.

Collaboratively solving the puzzle of the errors on the map with fellow students, and displacing their conflict onto a task rather than each other further promotes meaningful argumentation. This kind of strategy promises to create the "conflicting yet collaborative" environment that research shows may lead to better learning outcomes in the areas of science, than ordinary student discussions, where students' mostly repeat or reject what others have said (Alexopoulou & Driver, 1996; Chan, 2001).

It is evident, that for online discussions to be meaningful and beneficial to the learning outcomes of students, they must be attached to scaffolds that enhance students' levels of cognitive and metacognitive processing. Students may not
have the metacognitive skills to monitor their levels of knowledge without the use of a learning aide. Self-regulation, however, is an integral part of the successful learning process. The misconception mapping strategy is built around Travers and Sheckley's (2000) suggestion that student activities enhance self-regulatory behavior "from the inside out," more specifically, that they (1) guide students' self-beliefs, goal setting and expectations, (2) promote reflective dialogue, (3) provide corrective feedback and strategy modeling, (4) connect abstract concepts and (5) link new experiences to prior knowledge. The collaborative misconception mapping strategy was designed to prompt self-regulatory behavior, or at least to provide a self-regulatory scaffold or supplement to students, and assist student learning for those with low levels of such skills.

Collaborative misconception mapping involves an initial discussion prompt in the form of a teacher-constructed concept map that is in conflict with course material. This misconception map provides students with the opportunity to evaluate connections among potentially abstract concepts depicted on a tangible medium, and brings about the collaborative exploration of conflicting information, allowing students to gradually integrate and monitor their developing knowledge and comprehension with feedback from their peers. The error hunt and justification in the misconception mapping strategy serves as a discussion prompting, scaffolding and structuring tool without need for actual instructor involvement in the discussions themselves. This kind of structured collaborative strategy allows students to monitor their comprehension levels through their interaction with their peers as facilitators, which leads to recognition of
relationships between ideas or connections between abstract concepts (Roblyer & Edwards, 2000), and ultimately conceptual change.

This study investigated how collaborative misconception mapping may serve as a metacognition mediating tool, especially for those students with low levels of metacognitive skills, and how this strategy may promote better learning outcomes and learner satisfaction than traditional student discussions based on discussion questions. In addition, the levels of meaningfulness of discussions according to the intentional conceptual change process were compared to those of students participating in traditional online discussions based on open-ended discussion questions. The research questions addressed in this study follow.

Research Questions

1. Are there differences in the meaningfulness of students' discussions (their learning artifacts) among those in the following conditions:
   a. collaborative misconception mapping (CMM)
   b. traditional discussion question (TDQ)?

2. Is there a difference between the groups in the two collaborative activities in terms of post-test scores?

3. Does students' level of course-specific self-regulation differently influence their performance level under the two conditions?

4. Are there differences in students' perception of the two discussion activities in terms of helpfulness, frustration levels and type of challenges associated with them?
Hypotheses

It was hypothesized that students in the collaborative misconception mapping group will outperform subjects in the traditional discussion question group as follows:

1. Discussion scores of students in the collaborative misconception mapping group will be higher than those of subjects in the traditional discussion question groups.
2. Students in the collaborative misconception mapping group will outperform students in the traditional discussion question group on the post-test.
3. Regardless of their self-regulation levels, students in the misconception mapping group will perform well on the post-test, while low self-regulators in the traditional discussion question group will not do as well as their high self-regulator counterparts.
4. Students in the collaborative misconception group will generally perceive their activity as helpful and challenging, but not frustrating, unlike students in the traditional discussion question group.
CHAPTER 3

METHOD AND DATA ANALYSIS

Participants

Subjects were 52 undergraduate students in two face-to-face health sciences statistics classes at a large southwestern urban university, 24 in the collaborative misconception mapping group and 29 in the traditional discussion group. These students' professor, along with all other professors of statistics, was contacted via email regarding the possibility of offering the online studies as students' required assignments. Only two professors decided to participate in the studies. One set of data with 60 subjects had been inadvertently deleted by the professor in charge. 175 students were initially enrolled in the second professor's two classes. 106 students completed only parts of the two assignments, which each included a pre-test and a post-test, as well as online discussions. 69 students completed all parts of both assignments, however, one student had to be excluded because he completed his pre- and post-tests on the same day. Two students declined to release their responses for research purposes by typing "no" to question one, which asked whether students consented to their data being used for this study. The remaining 14 excluded students had struggled with non-responsive partners, having to complete the study with the researcher's
involvement. While participation in the studies was part of the course requirements, only less than one-third of students successfully completed all parts of both assignments. Although each of the two assignments was worth ten percent of students' final grade, some student comments indicated that the weight of their participation score was not clear to them, which led to such low participation levels.

The majority of subjects, more specifically, 87.5% of the misconception map group and 69% of the traditional discussion group, were female. The mean ages of the two groups were 22.3 and 24.5, respectively. The two groups' mean GPAs, credits registered and hours worked per week, as well as ethnic background were similar, as can be seen in Table 1.

Research Design

Data were collected online via WebCampus twice; first on the topic of standard deviation, then a month later, on the topic of correlation. Both studies were scheduled to take place following regular class lectures and activities provided by the students' professor, in order to ascertain that changes in students' scores could be largely attributed to the added online strategy.

Following oral instructions by the professor and further written instructions regarding the study requirements, students were administered an online pre-test on the respective topic. The pre-test included multiple choice and open-ended questions, as well as a demographic questionnaire (see Appendix A). Item
analysis indicated that the questions appropriately discriminated between high and low performers (see Table 2).

Students also responded to the Metacognitive Self-regulation subscale of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith-David, Garcia & McKeachie; 1991; permission for use in studies granted in 2002). The Metacognitive Self-regulation scale provided information regarding students’ self-regulation levels necessary for research question 3, to ascertain whether low self-regulators would benefit from Collaborative Misconception Mapping (CMM) similarly to high-self-regulators. The hypothesis was that low self-regulators in the CMM group would do as well on the post-test as high self-regulators in the CMM group and would outperform low self-regulators in the Traditional Discussion Question group. The rationale was that the CMM strategy would create stepping stones for low self-regulators that would aid them in the intentional conceptual change process, scaffolding them through potential obstacles that would make the low self-regulators in the Traditional Discussion Question group stumble.

Instruments

The MSLQ is an 81 item 15 scale questionnaire designed to assess college students’ motivational tendencies and their use of learning strategies as related to self-regulation, for a college course. The MSLQ contains two sets of questions, namely the Motivational and the Learning Strategy sections. The Motivational scale includes measures of students’ beliefs that they can accomplish something (i.e. self-efficacy), and locus of control measures. The scales that were not
utilized from the Learning Strategies section include students' use of rehearsal, time and study environment, as well as effort regulation. The rationale behind omitting some of the subscales was to shorten students' participation time. Even with such exclusions, the majority of students indicated that the pre-test questions were overly lengthy.

Factor analysis performed by the MSLQ's originator indicated that each item fell on one specific latent factor. According to reviews by Benson (1998) and Gable (1998), the internal consistency estimates of the scales range from .62 to .93 for the Motivational Scales and from .52 to .80 for the Learning Strategies Scales. Reviewers of the MSLQ believe that since only some of the subscales' internal consistency estimates were greater than .75, the reliability of what is being measured by the MSLQ is questionable. In addition, although one reviewer claims that the content validity of the MSLQ is supported through extensive literature on college student learning and teaching, evidence for the MSLQ's predictive validity and internal validity is deemed "somewhat deficient." The reviewer does acknowledge, however, that the instrument was designed based on a "comprehensive line of research" in the areas of motivation and learning strategies. The author of this paper, although acknowledging the MSLQ's limitations, chose the instrument over the Learning and Study Strategies Inventory (LASSI, Weinstein, Palmer, & Schulte, 1987), because the MSLQ assesses self-regulation on the course level rather than at a general level. This author agrees that although one may be considered a good self-regulator in one
area, they may not perform the same way when studying for a statistics course, for example.

**Procedures**

Students were randomly assigned to either *collaborative misconception mapping* (CMM) or *traditional discussion question* (TDQ) treatments to participate in online dyad discussions within a three week period (see Appendix B for misconception maps and discussion questions, as well as instructions students received). Low and high ability students were not grouped together intentionally because of the risk that the high ability students might locate the misconceptions on their maps without intervention from their partners, preventing the low ability partners from providing hints and explanations, which promise to be an important function of the collaborative misconception mapping activity. If two high ability students were grouped together, this premature discovery of misconceptions may not have a detrimental affect to the same extent, as these students' knowledge is already presumed high and possibly unaffected by this activity. If two low ability students were grouped together, they were expected not to stumble, but rather problem-solve together, due to the feedback function of the activity. A description of the two collaborative conditions follows.

The task of the *collaborative misconception mapping* group was to individually identify errors on misconception maps, then discuss these misconceptions within online dyads supporting students' arguments with information from their class materials or other sources. An example of an incorrect concept on a concept map would be *Node 1 - “Moderate to Strong Direct Relationship;” Link A -*
"means that;" Node 2 – "All Subjects Received High Scores on Both Variables". While one member of a dyad received a map with this flaw, along with another one somewhere on the map, the other member’s map included the correct Node 2, which should state "those subjects who received high scores on one variable also received high scores on the other variable". The two members of a dyad were given two different sets of errors within the same map to avoid "I agree" responses, and to give each student the means to help his or her partner as necessary with corrective feedback. To help structure the discussions in a meaningful way, each student was asked to start a separate discussion for each conceptual error they found by identifying the content in the subject field of their posting by a certain deadline, along with supporting evidence for their claim and their correction. Students were asked to remind their partners when supporting evidence was not provided and to help them locate such evidence if needed. They were given an example using an unrelated topic as a model on how the errors and evidence should be addressed to optimize clarity.

The partner student was required to reply to each discussion post with rebuttals or agreements regarding the error-status of the node or link, with at least one piece of supporting evidence in the form of a paraphrase from their instructional material. The student with the initial post was then to respond to his or her partner’s posting with at least one piece of supporting evidence of their own claim referenced from their reading material or other sources, whether it is in agreement or disagreement with their partner’s claim. If a student was having trouble finding errors, he or she was to ask for hints on the discussion board.
While his or her partner's map provided the solutions, initially, the partner was only supposed to point out the node or link with the error, without any explanations, so that the student had an opportunity to research the concept in question. With all errors corrected and discussed, both students possessed a corrected map, which could be used to review the concepts at hand. Once dyads decided that they had exhausted all errors and corrections, they were allowed to proceed to the post-test.

In this misconception mapping strategy, students become fully reliant on their dyad partners and their involvement. In order to minimize lack of participation of students due to their partner's negligence in posting on the dyad board by the initial posting deadline, when necessary, students were reassigned to other students who were also waiting for their initial partners to respond.

The traditional discussion question group consisted of student pairs who received discussion questions, some of which corresponded with each of the errors on the other group's map. More discussion questions were provided than number of errors on the other group's map, because directing students' attentions to the other group's errors themselves could have unfairly distorted the study results. This might have been so, because CMM students had the opportunity to review a concept map of the entire content, not strictly the content related to the errors, which could have possibly given them an advantage over narrowly focused discussion questions.

A discussion question that relates to the error example above (Node 1 - "Moderate to Strong Direct Relationship;" Link A - "means that;" Node 2 - "All

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Subjects Received High Scores on Both Variables”) would be “If researchers found that there is a strong positive correlation between “number of caffeinated drinks consumed per day” and “intelligence scores”, what would the makers of such drinks be able to legally claim?” Each student received two sets of discussion questions; their partners received different questions to allow for a larger range of topics to be discussed (see Appendix B for all instructional materials, including discussion questions).

Students were instructed to individually respond to their respective questions using a threaded discussion format. This allowed for each student to participate as discussion leaders and take initiative. One initial post, a response and at least a second response per question was required. Once all questions were addressed by both students, they were allowed to take their post-test.

Following each of the activities, in addition to the post-test that consisted of multiple choice and open-ended questions (Appendix A), students also answered a questionnaire regarding their thoughts about the strategy in which they participated. Cronbach’s Alpha was .49 for the pre-test and .53 for the post-test, which, according to Schmitt (1996) should still be acceptable, especially considering the low number of test items.

Data Analysis

This study investigated whether collaborative misconception mapping may serve as a self-regulation mediating tool for those students with low levels of metacognitive skills, and if this strategy promotes better learning outcomes and learner satisfaction than traditional student discussions based on discussion
questions. In addition, the levels of meaningfulness of discussions according to the intentional conceptual change process were compared to those of traditional discussions.

In order to compare the post-test scores of the two groups and investigate how low self-regulators fared under the two conditions in relation to high self-regulators, a 2 X 2 factorial GLM ANCOVA of post-test scores was performed, controlling for pre-test scores. Students' average "Metacognitive Self-regulation" scores from the ordinal 7-point Likert scale were changed to scores of 1 or 2 to represent high or low levels of self-regulation. This new ordinal scale variable was based on the median split method, where a number one was assigned to scores below 4.75, and a two to those higher than or equal to 4.75, the median "Metacognitive Self-regulation" score of subjects. While this method is generally used, it is also criticized as it may reduce statistical power. Qualitative scanning of scores, however, further strengthened the use of the score of 4.75 as the split point. While intuitively, 4 might be chosen as the midpoint on a scale of 1 to 7, where 1 means "Not at all true of me" and 7 means "Very true of me," some of the 12 items measuring self-regulation were marked high by all students, making their mean score uniformly higher. Item number 41, in particular, attracted scores of 7 from almost all subjects; it seems that even low self-regulators "go back and try to figure it out when they become confused about something in class." The use of the median split technique not only provided groups of approximately equal size, it allowed a few students with higher than 4 means to be classified as
low self-regulators, when their only score of 7 may have come from question number 41.

Repeated measures GLM ANCOVA was carried out to further investigate the pattern of pre- to post-test score change for low and high self-regulators, with GPA as the covariate. Depth of discussion scores were also compared using GLM ANOVA to ascertain whether the misconception mapping activity prompted more meaningful discussions.

Scoring of Dialogues

The discussion scoring guide (Appendix C) used for this analysis is based on theories described in this dissertation regarding learning in the areas of mathematics and science, as well as the importance of self-regulation and intentional conceptual change. The newly designed scoring method was deemed necessary because existing systematic theoretically based scoring methods do not measure qualities of discussions related to these aspects. The following are some examples of methods used by other researchers, which also informed this author’s scoring method design process, which will be described later in this section.

Kay (2004), relying on Bloom’s taxonomy levels (Anderson & Krathwohl, 2001), counted the number of statements on the knowledge level and beyond in discussion board messages, in addition to rating the clarity, quality and relevance of postings on a Likert scale. Inch and Warnick (2002) counted the number of statements and relationships in each message, categorizing them by levels of structure complexity based on number of claims and related pieces of evidence.
The Toulmin Model (1969) goes a step beyond this process and requires the evaluator of discussions to identify unstated inferences and supporting principles, analyzing each statement in addition to the relationships among them (Bendixen, Hartley, Spatariu & Sas, 2004). In their study of online student debate in a policy analysis course, Schaeffer, McGrady, Bhargava and Engel (2002) analyzed students' type of exchange to capture the nature of the student interactions by identifying whether 1) a post was related to a previous post, and if so, 2) whether it was agreeing or disagreeing, as well as 3) whether it introduced a new element to the discussion. Veerman (2000) looked for argument depth as well as balance by counting all arguments and also calculating the ratio of positively and negatively oriented arguments. In order to determine the type of argument, they looked for linguistic clues in sentences, such as "but," "however," "thus" as well as supporting examples or explanations. They also counted the number of questions asked, categorizing them as open- or closed-ended.

Based on theories of Chan (2001), Alexopoulou and Driver (1996), and Brown and Palincsar (1989), it seems that in the areas of science, online discussions' meaningfulness or depth should not only be evaluated based on number of disagreements, agreements, or type of responses. Rather, it might be more appropriate to assess levels of collaborative problem recognition, question formulation, co-construction of explanations or resolutions, justifications, reflection and search for new information based on references to course material. This is especially important, considering that it is the meaningfulness of discussions researchers try to determine, which can be best defined as
information exchange that “contributes to meeting course goals” (Bendixen, Hartley, Spatariu, & Sas, 2004), specifically, students’ engagement with course material, rather than the participation of students in discussions for the sake of initiating argumentation.

In order to measure depth of discussions, the scoring method used in this study entails the counting of statements that reflect self-monitoring or regulating behavior as detailed in the MSLQ and in the intentional conceptual change process, such as recognition of one’s level of understanding, as well as the processes of scientific engagement promoted by Alexopoulou and Driver (1996), Brown and Palinscar (1989), Chan (2001) and Lampert and Cobb (2003). The latter include the recognition of inconsistencies, formulation of questions (especially the question why) and co-construction of explanations/reflections. Points were assigned each time the raters observed statements or groups of statements that mirrored the activities outlined in the checklist. These activities included evidence of scientific inquiry, in addition to the aforementioned self-regulating behaviors as well as intrinsic goal orientation and help-seeking, a combination of which indicate the level of discussions’ meaningfulness. The following is the checklist (also seen in Appendix C) that was used to evaluate students’ knowledge building artifact (Bereiter, 2002), and examples of statements raters were looking for.

1. expression of intrinsic goal orientation (learning or performance oriented)
   - example: “I really need to find/learn the definition of ...”
2. realization of own level of understanding and/or need for more information
   - example: “I still don’t see how this relates…”, “I need to look this up…”

3. asking for location of source or clarification/corrective feedback
   - example: “Can you explain to me what…”, “Where is this in the book?”

4. collaborative explanation/elaboration on the meaning of concepts and relationships among them
   a. referring to evidence from course material
   b. not referring to course material
      - example: at least three posts, including two responses, that analyze course content material while providing some solutions to one or both of the students’ question(s)

5. pointing out peer’s level of understanding and/or providing location of source or clarification/corrective feedback
   - “look on page X of our book,” “I think that’s not correct…”

6. accepting conceptual critique and/or correction by peer – mini conceptual change or conception change
   a. by agreeing
      - example: “ok, now I understand”
   b. by elaborating
      - example: “I see, so what you mean is that…”
7. questioning conceptual critique and/or correction by peer (leading back to point 4 above)
   
a. by disagreeing
   - example: “I don’t think that’s correct.”

b. by elaborating
   - example: “I don’t think that’s correct because…”

The term *conception change* is used instead of conceptual change, because students may indeed just learn the true meaning of new concepts rather than changing their theory or thinking, which is a slow gradual process. This could be considered “tactile” conceptual change, as tactile metacognitive control is to metacognitive control that students possess on the long-run, as described by Pintrich (2000). Some examples of the above categories would be a student guiding another in the identification of a misconception, or providing an explanation that answers a conceptual question responding to the partner student’s inquiry.

Each frequency of behavioral occurrences was multiplied by the indicated number of points (Appendix C), and then summed to compile the score that represents the level of meaningfulness of student discussions. All points were multiplied by 2, except for 4a and 6b, which were multiplied by three points, and 7b, which was only worth one point. Point 7b was worth the least number of points, because while the student questions the partner’s critique, he or she does not state why and does not substantiate the disagreement by evidence. This would be similar to someone stating “I disagree” but not explaining why. While
there is a level of interaction, it is certainly not contributing to either student’s conceptual change. Point 4a received 3 points to indicate much desired level of engagement by partners in collaboratively elaborating while referring to an outside source. There are three very important activities evaluated by point 4a: collaborating, elaborating, and using a reference, each receiving one point. 6b also received 3 points because of the high level of involvement it represents, where a student not only realizes his/her misconception because of a peer’s critique, but also changes this misconception and provides evidence - depicting a 3-step mini conceptual change, which is the ultimate goal. Point 7b is worth the least number of points, because disagreement is not substantiated by evidence.

The inter-rater reliability of this scoring tool was initially somewhat low (63%), as the second rater was over-estimating the levels of meaningfulness of the misconception mapping group. These over-estimations were due to the fact that the second rater gave points for students’ discovery of errors on the misconception map. However, such activities were a required part of the misconception mapping activity, thus assigning points to individual error discoveries or corrections would have unfairly inflated the misconception mapping group’s discussion scores. After dialogue between the raters regarding the rationale behind each score given by each rater to all discussions, a 100% consensus was achieved. While there is no additional information on this scoring method’s reliability, its content is strongly supported by theory as described above.
CHAPTER 4

RESULTS

Post-test Group Differences and Interactions between Self-regulation Levels

In order to compare the post-test scores of the two treatment groups and investigate how low self-regulators fared under the two conditions in relation to high self-regulators, a 2 X 2 factorial GLM ANCOVA of post-test scores was performed, controlling for pre-test scores. Self-regulation levels were calculated based on mean scores on the Metacognitive Self-Regulation subscale of the MSLQ on questions, which address students' habit of questioning their level of understanding when studying for their class. Results for Experiment One, for which the students studied the topic of standard deviation, showed no statistically significant differences between the groups or within groups, however, this experiment was considered a practice assignment, so that the groups were given an opportunity to learn the strategies they were to use in the subsequent study. This was necessary as the students have not typically done online discussions before and did not have much experience with WebCampus or concept maps. For the first experiment, pre-test scores were generally very high for both groups, which interfered with any repeated measures analysis. It is important to
remember, that the pre-tests were taken by students after their instructor's lecture and/or activities so that the repeated measure analyses would reflect the increase in knowledge due to the online strategies themselves. Students apparently benefited greatly from the professor's instructional tools for the first experiment to an extent that their pre-test knowledge was too high to anticipate much increase following their participation in the online discussions.

This was not the case for Experiment Two, for which students studied the topic of correlation. Results of the analysis for Experiment Two suggest that the collaborative misconception mapping group (mean=19.49, se=.639) outperformed the traditional discussion question group (mean=17.12, se=.587) on the post test (F(i,47)=7.4, p=.009, Partial Eta Squared=.14, Observed Power=.76) (see Table 3 for estimated marginal means and standard errors; and Table 4 for GLM ANCOVA statistics). It is also important to note, that while not statistically significant, some patterns of interaction were observed. Low self-regulators in the misconception group had similar estimated marginal mean post-test scores to the high self-regulators in the same group (19.58 and 19.41 respectively) and somewhat outperformed even high self-regulators in the traditional group (18.25). On the other hand, low self-regulators in the traditional group had the lowest post-test scores of all subgroups (15.99) (Figure 3 shows graphical representation of this phenomenon). This phenomenon was more apparent in the results of repeated measures ANCOVA analysis, where the interaction effect is approaching significance at .08, as can be seen in the following section.
Pre-test to Post-test Mean Differences and Interactions between Self-Regulation Levels

According to the results of repeated measures GLM ANCOVA, there was a statistically significant difference between the two groups' change in knowledge with GPA as the covariate ($F_{(1,43)}=4.35$, $p=.043$, Partial Eta Squared=.092, Observed Power=.532) (see Table 5 for means and standard deviations; and Table 6 for Repeated Measures GLM ANCOVA statistics). More specifically, the misconception group gained 3.5 points while the traditional group gained 1.7 points. The interaction effect for group membership and self-regulation level approached significance at $p=.08$ ($F_{(1,43)}=3.2$, Partial Eta Squared=.069, Observed Power=.417), indicating an emerging pattern where low self-regulators in the collaborative misconception mapping group had an increase of 3.9 points, while low self-regulators in the traditional group actually had a half point decrease in their mean score (see chart in Figure 4).

Discussion Score Differences

Results of GLM ANOVA of group level discussion depth scores showed that the misconception mapping activity prompted more meaningful discussions ($F_{(1,35)}=7.93$, $p=.008$, Partial Eta Squared=.185, Observed Power=.782) as measured by the scoring instrument designed based on an intentional conceptual model for the purpose of this study. The misconception mapping group's mean score was 2.75 (sd=3.31) and the traditional group's mean score was .57 (sd=1.12) (see Table 7 for means and standard deviations and Table 8 for GLM
ANOVA statistics). Levene's Test for Equality of Variance was significant (F=17.88, p=.000), and, while ANOVA is relatively robust, this is a limitation of the study.

Qualitative Analysis of Discussions

In any analysis, it is important to triangulate the data to verify the validity and reliability of our quantitative measurement and calculations. The qualitative description or analysis of student discussions as well as students' feedback regarding the activities in which they participated is invaluable. The 7-point checklist designed for the scoring of discussions for this study (described in Chapter 3) not only allowed for the quantitative analysis of discussion depth as it relates to learning outcomes or levels of self-regulation, but for the qualitative interpretations of the kind of meaningfulness the discussions actually contained. For example, it is interesting to see the connection between the discussion scores, the type of interaction between students, and subjects' post-test scores, which further support the quantitative evidence above.

The highest discussion score in the misconception mapping group was 11 compared to the highest score of 4 in the traditional group. One of the students with the highest discussion score in the misconception group had the largest increase in scores from pre- to post-test, namely, from 7 to 17.5; her partner's score increased from 16 to 22. Such a large increase was also evident for the CMM student with the second highest discussion score of 7, with a pre- to post-test score change of 9 (from 12 to 21). These increases occurred even though all
three students’ self-regulation scores were low. Following is an excerpt that clearly shows the success of the discussion by the CMM group with the highest discussion score, despite their low self-regulation levels:

Partner 1: “I am not really understanding the relationship when it is negative. I thought it was like less fast food would mean fewer calories.” (realization of level of understanding, 2 points)

Partner 2: “I say go back to chapter five. Look at page 79 and table 5.1. This will be very helpful.” (leading to collaborative elaboration on the meaning of content with reference to source, 3 points)

Partner 1: “Ok, you are right. A negative relationship is something like the following: ‘The less time you take to complete the test, the more you’ll get wrong.’ I thought it was something like ‘the less time you take to complete a test, the less you will get wrong,’ but that is a positive relationship, such as ‘the more time you spend studying the higher your grades will be’. I straightened it out finally. (conception change with elaboration, 3 points)

One can see the meaningful conversation that took place between these two students, and how certain they were of their answers because of reference to their book and the fact that they had each other’s solutions. On the contrary, the traditional discussion group with the highest score of 4, which is much lower than their collaborative misconception group counterparts, never reached this level of certainty, and partners, one with low and the other with high self-regulation scores, were talking at each other rather than with each other.
Partner 1: “A positive relationship would be if more sugar is consumed the cholesterol levels are higher.”

Partner 2: “I think you’re correct. A positive relationship would mean higher sugar consumption with higher cholesterol levels.... I think.

Partner 1: “Now that I have done a little more reviewing I think .... Do you think I’m on the right track?”

Partner 2: “Your guess is as good as mine. Whatever... do you have any questions?”

The students’ were left without feedback, which could have contributed to possible low post-test scores. Luckily for this dyad, their pre-test scores were already high (22 and 18) and their post test scores remained high (22 and 22). The same dyad had the following interaction also: “I feel like I understand this one. I think the instructor said that we were supposed to respond to each question four times. If that is true, then I’m just going to tell you about what I watched on TV because I don’t think I am actually educated enough to come up with four responses.” Had the students in this dyad had low pre-test scores, their discussion would likely not have contributed to higher levels of learning.

The majority of discussions among the traditional discussion group were similarly lacking in substance. As responses to their partner’s initial answers to the discussion questions, students often responded with “I agree” or “I’m confused” with no visible solutions. One student stated “I agree with your answer. It seems we answered the questions in similar ways which is good because it must mean we are both correct.”
This guessing game is exactly what may make traditional discussions fail. Students do not have a way to verify the correctness of their answers. They rely on the opinions of other students. It is like driving a car with muddy rearview and side view mirrors. The misconception mapping strategy helps clean the mirrors; it helps students realize their level of understanding, correct misconceptions and verify with their partners whether they have reached the necessary “conception change”. This is possible because students possess the corrections of their partners’ errors, so that when someone is not able to find an error or has the wrong correction, his or her partner can just look at their own map that shows the partner’s correction and can guide him or her with hints and suggestions until all puzzles are solved.

Following is another example from a misconception mapping group whose interaction, while not the best example of what collaborative misconception mapping may elicit, still shows that the feedback function eliminates the uncertainties of traditional discussions. Even though their discussion score was the same as the highest score in the traditional discussion group (4), this dyad did not have uncertainties in their discussion, but rather, they were able to confirm and prove each other’s comments.

Partner 2: I think the one that is wrong on my map is the bubble that says “students with low GPAs attend fewer parties” ... I think the bubble should say students with lower GPAs attend more parties because the bubble [...] is speaking about an inverse relationship. I cannot figure out the second one that is wrong. Can you help me?
Partner 1: You are correct! Your clue is: try reading in the book about what the relationship is when the correlation range is on the positive side. My guess: is it the bubble that says ‘subjects with low scores on one variable …’ (3rd bubble straight down from the correlation bubble). If not, please give me some hints for both errors. Thanks!

Partner 2: You are correct, that is one of the wrong bubbles… look how it says there is no relationship or weak relationship.. so it will not be an indirect (one goes up the other will go down – negative) or direct (both go up – positive).

Keeping that in mind, look at this website:
http://www.answers.com/topic/correlation. Scroll down and look under investment and read ‘Investopedia says:’ (providing location of source or clarification/corrective feedback, 2 points). For the second wrong bubble read the definition about correlation on our vocab sheet. Our professor actually made a comment about this because so many people confused it with something else on the vocab part of our test. For my second answer the wrong statement is the one that says “numbers between approx. positive point five …” the right answer should be “numbers ranging between .00 and positive 1.00.

Partner 1: For your second answer you are in the right direction, but look inside the bubble. For my answer: is the bubble that says “a statistical procedure that compares…” the error because correlation compares groups of people on more than one variable?

Partner 2: really close, but read page 78 under types of correlation coefficients. (providing location of source or clarification/corrective feedback, 2 points).
Qualitative review of the data further strengthens the findings regarding the effectiveness of the collaborative misconception mapping strategy: students in the traditional discussion question group with low self-regulation scores consistently achieved scores of zero on the discussion rating scale, and score decreases from pre- to post-test, such as 20 to 16, 20 to 16.5, 19 to 9. On the other hand, the knowledge scores of students with low self-regulation levels in the collaborative misconception mapping group never decreased, and their discussion scores were similar to those in the misconception mapping group whose self-regulation scores were high. Only those low self-regulators received discussion scores of zero in the misconception mapping group, who figured out their errors before having a chance to discuss. These students still had large increases in their knowledge, including one student who had an increase of 11 points from a pre-test score of 10.5 to a post-test score of 21.5.

Analysis of Student Feedback about the Strategies

In addition to an activity's effects on student learning outcomes, students' perceptions of these effects are invaluable. At the end of their post-test, students were asked to share their opinions about the activity in which they participated. Some multiple choice questions addressed the level of frustration and helpfulness associated with the activities. It seems that more students perceived the collaborative misconception mapping activity to be helpful (83% versus 69%), and three students (10%) even rated the traditional collaborative activity as one that did not increase their knowledge at all. When asked to rate the kind of
frustration associated with the activities, only 12.5 percent rated the misconception activity "as somewhat frustrating and it interfered with learning," while 25 percent of the traditional discussion group rated their activity as such. Similarly, 37 percent of the misconception group and 32 percent of the traditional group thought that the activities were "frustrating but worth it," and 46 of the misconception group versus 36 percent of the traditional group deemed their activities "not at all frustrating."

Open-ended questions addressed whether the activities helped students see how well they understood the material at hand (self-regulation), how much the activity contributed to consulting books or online sources, and what students liked or disliked about the activities. Students' responses were color-coded in Microsoft Excel, and then tallied, according to common categories created by their answers. The number of responses that represented things like "helped my understanding of the content," "took too much time," or "helped to see if what I think is correct is true" were counted.

Some interesting patterns that emerged from students' open-ended answers were the following:

1. Approximately the same, or 21 percent (5) of the misconception group and 24 percent (7) of the traditional group said that they liked the discussion aspect of the activity most.

2. 50 percent (12) of the misconception group and 31 percent of the traditional group said that they did not like having to interact with or wait for a partner.
3. 34 percent (10) of the traditional group and only 8 percent (2) of the misconception group shared that they did not like the length of time it took to complete the activity.

4. Over 54 percent (13) of the collaborative misconception group commented that the activity helped them better understand the concept of correlation, compared with only 31 percent (9) of the traditional discussion group.

5. 21 percent (5) of the misconception group, versus only 7 percent (2) of the traditional group commented that the activity was fun.

6. 33 percent (8) of the misconception group and none of the traditional group commented that the activity helped them organize or outline the content.

7. 21 percent (5) of the misconception group and none of the traditional group said that the activity helped test their knowledge to see if what they think they know is correct. On the contrary, 17 percent (5) of the traditional discussion group actually commented that they still don’t know what correlation truly is. One student said: “I still don’t know what negative correlation means. Things from my partner to the discussion questions and the material just didn’t seem consistent”.

8. 21 percent (5) of the misconception group said that the activity gave them confidence about what they know.

9. On the contrary, one comment from a student in the traditional group said: “It didn’t really help me learn much… I like to see if my answer is correct or not. I don’t necessarily trust my partner who I don’t even know.”
The above results indicate that the collaborative misconception mapping strategy fared better than the traditional discussion question activity. Students in the collaborative misconception mapping group discussed the content at greater depths, received higher post-test scores and perceived the activity to be helpful and even fun. While only at a .08 significance level, the results also suggest that the misconception mapping students with low self-regulation might outscore not only students with similar unfavorable characteristics in the traditional discussion group, they might also perform better than those students in the traditional discussion group who have high self-regulation levels. The following chapter discusses the importance of the above findings in terms of the theoretical framework on which the design of the strategy relied, in light of the continued boom of online education purportedly supporting social constructivist learning environments as envisioned by Vygotsky and more recently critiqued by Mayer and Kirschner.
CHAPTER 5

DISCUSSION

The Need for Research and Theory-based Interventions in Online Education

Higher education is continuously being transformed by the Internet revolution: traditional universities are increasingly and sometimes reluctantly offering online or hybrid courses, and their for-profit counterparts are making hundreds of millions of dollars annually relying heavily or even fully on online learning (Cronin & Bachorz, 2005). Online discussions are a large part of this revolution, as they are also perceived to be in line with popular social constructivist educational theories. Typical descriptors of expected and accepted learning outcomes of online discussions under the umbrella of such Vygotskyan learning theories (Vygotsky, 1978) are “informal, tacit and continuously developing” with participants “exploring information rather than accepting what the teacher determines to be learned” (Salmon, 2004). To many, this translates into letting students discuss topics on their own without guidance from an instructor. Nevertheless, Vygotsky’s theory is based largely on the idea of scaffolding, or guidance by a more capable peer and teacher. While Vygotsky might place a greater emphasis on collaboration among peers than on direct knowledge
transfer from a teacher (Bryan, 1996) this author’s view is that Vygotsky envisioned students constructing knowledge with the aid of a knowledgeable teacher who provides a framework for learning, rather than students constructing their own framework without a stable foundation, which can lead to a collapsing card castle of information and misinformation in the wind of unguided exploration.

It is this “learning environment with little or no guidance” (p. 14) that Mayer (2006) warns educators about. In his view, effective constructivist methods would 1) involve cognitive rather than behavioral activities, 2) involve instructional guidance rather than unguided discovery, and 3) have curriculum related foci.

Collaborative misconception mapping strategy addresses all three of these points by providing a 1) cognitive game 2) with implicit scaffolding by an expert 3) regarding the educational content/concepts at hand. On the other hand, unguided online activities that rely on students answering questions and discussing their answers with a peer, will likely result in information overload, where students may not ever find the “to-be-learned material” and thus fail to make sense of it, organize it, or integrate it with other organized knowledge (Mayer, 2006, p. 17).

Such unguided exploration, as can be seen in the results of this study, may lead students into meaningless and potentially damaging discussions, uncertainty, frustration, and unfavorable learning outcomes. Instructors must realize that the mere act of participating in an online discussion will not develop students’ appropriate individual cognition out of social interaction (Krejins et. al, 2002). If we can assume, in today’s social constructivist online learning
environments, that "interactive linguistic exchanges among people play an essential role in the elaboration and perpetuation of scientific concepts" and that the "acquisition of these concepts is the result of social interaction" (Dimitracopoulou, 2005; p. 115), then scaffolding must be provided, and the online social interaction must be designed carefully with learning theories in mind.

A recent review of research in the area of online discussion quality and the factors that impact it confirms that there is a lack of theoretical foundation regarding online learning, which is partially due to the fact that there is not enough research conducted in the area (Spatariu, Quinn, & Hartley, 2007). According to Dimitracopoulou (2005), while studies have tested the effectiveness of some instructional strategies designed to enhance online discussions, the research work regarding the trade-offs related to online collaborative learning environments is "merely at a premature state" (p. 120). Yet the popularity of online discussions is soaring without much confirmation regarding their effectiveness. It is likely that unguided online discussions are the norm. This is alarming considering the fact that characteristics of instructional tasks have a great impact on the quality of students' discussions (Kumpulainen, 1996) and learning outcomes (Cohen, 1994; O'Donnell & Dansereau, 1992). If this task is non-existent or poorly planned, where online peer interactions are without appropriate theory-based scaffolding recommended by Vygotsky himself, subsequent learning outcomes will suffer.
According to Mayer (2006), the best strategy probably is one that guides "students' cognitive processing" while focusing on "clearly specified educational goals" (p. 17). The present study investigated how collaborative misconception mapping, a strategy designed to provide this much needed cognitive process-scaffolding, would benefit students who participate in online discussions. The findings indicate that the positive effects of collaborative misconception mapping strategy surpassed those of the traditional discussion question activity by 1) enhancing the meaningfulness of discussions, 2) improving learning outcomes, even for those with low self-regulation, and by 3) bringing forth affirmative learner perceptions regarding the activity itself. The following section includes a description of these findings as compared with or informed by those of other researchers in the area. This synthesis will then be evaluated in terms of the theoretical framework that informed the design of the collaborative misconception mapping strategy. Related educational implications and limitations will also be outlined, followed by this author's conclusions.

Enhancing the Meaningfulness of Discussions

As can be seen in the Results section above, students in the collaborative misconception mapping group had more meaningful discussions than students in the traditional discussion question group, as measured by a scoring method based on the intentional conceptual change model by Sinatra and Pintrich (2003). When evaluating the quality of discussions, the raters were scoring evidence of scientific thinking and steps of the intentional conceptual change
process, or what Mayer (2006) calls "students' cognitive processing". This would include student actions such as formulation or clarification of ideas (Lampert & Cobb, 2003); justifications, reflections and search for new information (Brown & Palinscar, 1989) as well as recognition of inconsistencies, formulation of questions and co-construction of explanations (Alexopoulou & Driver, 1996; Chan, 2001). This is what the collaborative misconception mapping strategy was designed to promote. The hypothesis was that if students can engage in such activities together as a team with necessary implicit scaffolding from an expert teacher in a computer-supported collaborative learning environment, they would achieve better learning outcomes.

This is the kind of evidence Veerman (2000) was searching for in a study of the Belvédère system, a CSCL Scripting tool that was designed to make discussions more meaningful by providing necessary structure. Although this tool helped structure student interaction, it did not provoke discussion (Veerman, 2000). While van Boxtel, van der Linden, Roelofs and Erkens (2002) found that students' co-construction of concept maps, on the other hand, did provoke discussions, but it did not prompt explanations of relationships and descriptions of phenomena, and some of the most frequent misconceptions did not emerge for discussion among students. On the other hand, by its design, collaborative misconception mapping unearthed misconceptions, prompted explanations, and provoked discussion. It is because its design allows for increased student engagement through co-critiquing an external source and co-construction of a joint solution related to concepts at hand, while fostering metacognition.
Collaborative misconception mapping is based on a synthesis of the optimal design features of discussion prompting and mediating strategies as described in previous sections. It utilizes a completed, but flawed concept map created by a fallible authority to pose as an initial conflict. Students critique and correct this fallible authority as a team, instead of trying to disagree with each other just to get their participation points for their online assignment. When asked to discuss questions without a strategy or tool in place, students may run into difficulties disagreeing with each other for personal reasons, or because the educational material simply does not allow for much disagreement. If students in such unguided online discussions do not find something to disagree about, they do not have a choice but to simply say “I agree” and maybe paraphrase their peers’ original posting. This was evident in typical responses by students in the traditional discussion group, who tended to paraphrase their partners’ posts or respond with “I agree” and even “Your guess is as good as mine.” This was not the case for students in the collaborative misconception mapping strategy group; they were more likely to co-critique and correct misconceptions as a team, in other words, make meaning together. This is not to say that they reinvented the statistical concept of correlation and created a new meaning; it simply means that they created new meaning within themselves with each others’ help, by recognizing, undertaking and clarifying misconceptions. They could not have done this without the guidance of the misconception mapping strategy, which provided implicit hints from an expert.
While students in the traditional discussion question group may have had lengthier individual posts, their discussion scores were often still zero, because their posts did not reflect collaboration depicting the process of intentional conceptual change. Mayer (2006) agrees that it is not the quantity of discussion but the “degree to which they promote appropriate cognitive processing” (p. 17) that will contribute to better learning outcomes. Evidence of such cognitive processing is what the discussion rating scale in this study was designed to measure, and such processing is what the collaborative misconception mapping strategy was designed to promote. Further evaluation of the misconception mapping strategy in terms of compatibility with instructors will be detailed in the Educational Implications section of this chapter, but now it is essential to learn about how this strategy affected learning outcomes, especially those of students with low metacognitive skills.

Improving Learning Outcomes for those with Low Self-regulation Levels

The misconception mapping strategy was valuable in not only helping students engage in more meaningful discussions, but also to achieve higher learning outcomes. On the other hand, the mere act of participating in the traditional online discussions did not successfully develop meaningful discourse or transform appropriate individual cognition out of social interaction (Krejins et. al, 2002). Not only did the collaborative misconception group had a higher pre-test to post-test gain than the traditional group, low self-regulators in the
misconception group had a tendency to have a larger increase in their test scores than low self-regulators in the traditional group, who actually had a half a point decrease in their test scores. This finding is interesting in the light of similar findings of decreasing scores by low-aptitude students who participated in unguided learning activities (Kirschner, Sweller, & Clark, 2006). In contrast, the collaborative misconception mapping strategy provided necessary guidance and functioned as a metacognitive monitoring or promoting tool that helped students identify misconceptions, aided the self-regulation process, leading to higher levels of learning or conceptual change.

*Mimicking the Intentional Conceptual Change Process*

Fitting with Mayer's (2006) recommendation that collaborative activities must promote “students' cognitive processing,” collaborative misconception mapping embraces the importance of metacognitive skills, more specifically self-regulation. It also borrows from the *Questioning the Author* approach (Beck & McKeown, 2001) to promote scientific inquiry through concept organization, planning, and monitoring with the aid of a concept map. This is especially important when explicit self-regulation instruction as recommended by Randi and Corno (2000) is not possible due to time constraints or, as in case of online education, physical distance between instructor and student. Instead of explicit training to use metacognitive skills, in collaborative misconception mapping, the learning task itself is designed to structure student discussions and student actions according to the steps of the intentional conceptual change process, thus resulting in temporarily heightened levels of self-regulatory behavior and
ultimately more meaningful content related exploratory talk, and conception change. This heightened level of self-regulatory behavior is specific to the task at hand, as the misconception map and related activity can only provide cognitive stepping stones related to the content at hand. This is not a pitfall of the strategy, but rather, a natural outcome of its design, which is to address “clearly specified educational goals”, as promoted by Mayer (2006).

By addressing such educational goals and guiding students through the cognitive process of intentional conceptual change, students were able to achieve more meaningful discussions and positive learning outcomes. This can be seen in the concluding thoughts of a previously highlighted discussion post by a student in the collaborative misconception mapping group:

“Ok, you are right. A negative relationship is something like the following: ‘The less time you take to complete the test, the more you’ll get wrong.’ I thought it was something like ‘the less time you take to complete a test, the less you will get wrong,’ but that is a positive relationship, such as ‘the more time you spend studying the higher your grades will be’. I straightened it out finally.”

This student reached conception change via the metacognitive tools presented by the strategy. He realized his existing misconception that was not apparent before, thought about it, asked for and received help from his peer who gave hints and sources of information, read the information, thought about it more, and then the “aha” moment arrived. “I straightened it out finally.” This is an exclamation sought after by social constructivist instructors; it means that the
student discovered and corrected his own misconception without explicit involvement from the instructor, relying on the strategy at hand and help from a well-informed peer. In other words, the student co-constructed knowledge, just as Vygotsky must have envisioned social constructivism to be (Flavell, Miller & Miller, 2002). The process of conceptual change clearly happened internally as Piaget theorized, without direct instruction from the teacher, however, with scaffolding from a well-informed peer through a computer-supported collaborative activity, without which the student may have internalized misconceptions as facts.

The conception change of the student in the above example was induced socioculturally through a comprehension activity with the support from peers and inherently led by the teacher (Hatano & Inagaki, 2003). The following shows step-by-step how the teacher-initiated peer-guided intentional misconception mapping strategy lead this student to a desired conception change level with the mimicked steps of the conceptual change process (Sinatra and Pintrich, 2003) by prompting self-regulating behavior and inducing collaborative scientific reflection:

1. This student developed deliberate goal orientation to find the misconception on the map. Unable to find it, the student asked his partner for hints. Once the misconception was pin-pointed by the partner student regarding the example provided for the concept of “negative correlation”, the student had a new deliberate goal to search for new information and ask for help if needed.
2. The student became aware of his own existing knowledge through lack of discovery of misconceptions initially; he could not find the error, and even after the partner pin-pointed the location, he was unsure why the concept was incorrect, until the partner student referred him to an online source. He said: “I am not really understanding the relationship when it is negative. I thought it was like less fast food would mean fewer calories.”

3. The student responded to the inconsistent data, in the form of the located misconception on the map, which lead to the questioning of existing conception and searching for supporting evidence. The partner said: “I say go back to chapter five. Look at page 79 and table 5.1. This will be very helpful.”

4. The students collaboratively weighed the plausibility of misconceptions while trying to provide explanations to correct conceptions.

5. The dyad collaboratively solved the misconception on the map while comparing rival conceptions through high engagement, such as questioning, discussions, help-seeking and hint providing.

6. All this resulted in critical reflection by collaboratively engaging thoughtfully with ideas throughout the entire process.

7. Students provided and received feedback in the form of hints or pinpointing of concept confusion throughout the entire process.

Most students in the traditional discussion group did not experience this process and did not arrive at an “aha moment.” Some of them may have gotten stuck at step 1, by never developing deliberate goal orientation to learn or find
misconceptions because the task of answering questions did not prompt such cognitive behavior. Others may have been motivated to complete their assignments, and answered the discussion questions, but did not become aware of their existing knowledge, because their partners were uninformed and could not provide appropriate feedback. Without such feedback, students posted comments like “Your guess is as good as mine” or “I agree with your answer. It seems we answered the questions in similar ways which is good because it must mean we are both correct.” These students were clearly not certain about their knowledge and might have learned each other’s incorrect interpretations. This is typical of “pure-discovery” methods in science learning, where students are not given directions or guidance (Kirschner, Sweller & Clark, 2006).

On the other hand, students in the misconception mapping group had the opportunity to see if what they knew was correct, not only by comparing their knowledge to the map, looking up information in the book or on the Internet, but also by having a student partner confirm or challenge their comments on the discussion board with certain information from the instructor, rather than opinion. Thus, students in the misconception mapping group may have better monitored their levels of understanding and felt the need to further study the content (Pinrich & Schrauben, 1992), as prompted by the misconception verification and feedback feature of this strategy. These students also became more engaged in the evaluation of concepts at hand through their error search, which lead to better learning outcomes than for those who might have simply scanned the material for quick answers to traditional discussion questions.
Even though the instructor was not overtly involved in the misconception mapping activity, the features of the activity were designed to provide covert expert feedback via the concept map and peers' responses educated by the corrected bubbles of the map. While the students in the traditional discussion question group were trying to learn by searching for information, students who used the collaborative misconception strategy were "learning by thinking" as Mayer recommends (2006, p. 17). Interestingly, students' own perceptions regarding the effectiveness of the collaborative misconception mapping strategy mirrored its actual effectiveness, as can be seen in the following section.

Bringing forth Affirmative Student Perceptions of the Strategy

The collaborative misconception mapping strategy enhanced student engagement with the content at hand and students' self reports regarding their opinions of their respective activities reflect their accurate sense of the benefits of their assigned strategies. Almost one fourth of the students in the misconception mapping group and none of the traditional group reported in response to an open-ended question regarding what students liked most about the activity itself, that it helped verify the level of their knowledge and gave them confidence. Furthermore, many students in the traditional collaborative group voluntarily reported that they still did not understand the content covered in the activity. In one of these student's words: "Things from my partner to the discussion questions and the material just didn't seem consistent." Another student in the
traditional discussion question group commented: "It [the activity] didn't really help me learn much... I like to see if my answer is correct or not. I don't necessarily trust my partner who I don't even know."

Over half of the collaborative misconception mapping group commented that the activity helped them better understand the concept of correlation, compared with only one third of the traditional discussion group. Some students in the latter group even commented that the traditional discussion activity did not enhance their knowledge at all. Over one third of the misconception group and none of the traditional group commented that the activity helped them organize and outline course content. As expected, a large percentage of students noted "having to interact with a partner" as their least favorite part of the project. This percentage was larger for the misconception mapping group, and still they outperformed their traditional discussion question counterparts on the post-test and in terms of the depth of their discussions, indicating that the strategy was able to override the potential negative effects of students' preference for individual assignments. A larger percentage of the traditional group, however, commented on the time the assignment took to complete being too lengthy, and rated the traditional discussion activity as "somewhat frustrating and interfering with learning."

As we have seen, traditional online discussion activities are often characterized by not only inadequate collaboration but also low levels of learning and learner satisfaction (Hallett & Cummings, 1997; Kreijns, Kirschner, & Jochems, 2002). While it is not possible to design every assignment to be entertaining and fun, it is important that students feel motivated to complete
them, and feel like their knowledge levels have increased. After all, assignments exist for the mere purpose of adding to students' knowledge. If students perceive their assignments to be ones that do not add to their level of knowledge, or are too time-consuming because of their length, difficulty levels, or frustration associated with them, then they will not complete them and thus fail to take advantage of their intended educational benefits. It is crucial that the completion of in-class and take-home assignments make students feel like they have learned something. This might give them not only self-confidence for the course material itself, but also self-efficacy for subsequent assignments, leading to a higher number of assignments completed and submitted, and better learning outcomes in the end. The collaborative misconception mapping strategy, while in need of some revisions, provided a more valued activity for students, better learning outcomes for students with all levels of self-regulation, as well as more meaningful discussions.

Theoretical Implications

An evaluation of the collaborative misconception mapping strategy in terms of the theoretical framework that guided its design (see Figure 5), as well as an account regarding deductions related to its place in this author’s hypotheses and social constructivist learning environments follows. The collaborative misconception mapping strategy explored in this study was designed based on sound learning theories to address the pitfalls of traditional online discussion question activities, such as low content-engagement on the parts of the students,
discussion posts that are not content oriented, and lack of learning enhancement due to uncertain student posts. The strategy was especially designed to scaffold the discussion and learning process of students with low self-regulation levels.

The following section describes, in terms of a supporting theoretical framework, how the collaborative misconception mapping strategy 1) implicitly facilitates intentional conceptual change and meaningful discussions; 2) provides explicit feedback from an “expert peer” and a teacher-constructed concept map; 3) induces critiquing of an external representation of misconceptions, enabling students to collaboratively resolve inner conflict. First, a brief depiction of the theoretical framework in question follows.

As detailed in the Literature Review, online discussions are often unsuccessful in terms of their processes and outcomes, and part of the reason is that instructors expect individual knowledge to independently unfold from student collaboration. This may be due to a misinterpretation or misuse of sociocultural theories of learning, more specifically, theories of Lev Vygotsky (1896-1934). Vygotsky’s sociocultural theory does hold that cognition is a result of active learning in a social context; however, in his view, this social interaction must happen “through the guidance and support of an adult” (Flavell, Miller & Miller, 2002, p. 23) or expert. This can be seen in Vygotsky’s concept of the zone of proximal development, which highlights the role of an expert in gradually channeling a student from their current level of cognition to a desired level. This happens through what Vygotskyan theories refer to as scaffolding, or helping a student through difficulties in a student-sensitive way (Flavell et al., 2002). This
scaffolding can be in the form of direct leading questions by an expert, or embedded in expert-designed activities that make students realize their own levels of knowledge and the goal knowledge-level, while providing strategies to reach that goal. The latter type of guidance is especially important for online learning, as the Socratic-like dialogue may not be possible due to the absence of a physical teacher. As evidenced in this dissertation, students by themselves cannot generally engage in such dialogues in online discussions. Thus in an online sociocultural setting, a need arose for what can be characterized as an expert-designed-artifact-mediated scaffold, which allows teachers to indirectly guide students within and through the zones of proximal development.

Collaborative misconception mapping, a “knowledge building strategy” (Bereiter, 2002), is such a learning scaffold centered around collaboratively finding and correcting common misconceptions on an expert-designed concept map, with the help of an online partner. In this strategy, students re-build a “cognitive artifact” online, or a collection of ideas and thoughts, through the processes of scientific engagement promoted by Alexopoulou and Driver (1996), Brown and Palincsar (1989), Chan (2001) and Lampert and Cobb (2003). More specifically, the strategy induces the formulation or clarification of ideas, justifications, reflections and search for new information, and recognition of inconsistencies, as well as the formulation of questions and co-construction of explanations. The strategy mimics the intentional conceptual change process, as envisioned by Sinatra and Pintrich (2003), thus embracing the importance of metacognitive skills, more specifically self-regulation (Zimmerman, 1994), while
borrowing from the *Questioning the Author* approach (Beck & McKeown, 2001) to promote scientific inquiry through concept organization, planning, and monitoring with the aide of a concept map.

This scaffold does not expect students to possess high levels of self-regulation. Instead, it implicitly assists students who cannot monitor their levels of knowledge or do not intrinsically strive to reach learning goals, while engaging them in meaningful discussions with a partner online, thus leading them to the next level of the zone of proximal development, namely, a “conception change.”

The following section describes, in terms of a supporting theoretical framework, how the collaborative misconception mapping strategy 1) implicitly facilitates intentional conceptual change and meaningful discussions; 2) provides explicit feedback from an “expert peer” and a teacher-constructed concept map; as it 3) induces critiquing of an external representation of misconceptions while enabling students to collaboratively resolve inner conflict.

*Implicit Facilitation of the Conceptual Change Process and Meaningful Discussions*

As detailed in the previous section, the blueprint of the *collaborative misconception mapping strategy* (as seen in Figure 5) incorporated the following findings: 1) cognitive and metacognitive skills are crucial for optimal student learning; 2) discourse among students must be appropriately scaffolded to enhance levels of cognitive and metacognitive skills as well as learning, by providing meaningful awareness of one’s knowledge levels; 3) concept mapping activities can enhance discourse among students, as well as their cognitive and
metacognitive processes, such as organization and monitoring, and they also have a positive affect on the learning outcome; and 4) critiquing an external source can lead to more meaningful discussions. In addition, since the current study’s investigations surrounded the content of statistics, it was important to integrate findings regarding science and/or mathematics instruction, namely, 5) discussions must foster formulation or clarification of ideas (Lampert & Cobb, 2003), justifications, reflections and search for new information (Brown & Palincsar, 1989) as well as recognition of problems [or inconsistencies], formulation of questions and co-construction of explanations (Alexopoulou & Driver, 1996; Chan, 2001).

In line with such findings, the structure of the misconception mapping strategy, as can be seen in Figure 2, relies on the intentional conceptual change process as described by Sinatra and Pintrich (2003). The process of intentional conceptual change presupposes that learning takes place under the learner’s own control and metacognitive process. Intentional conceptual change, however, rarely happens as students often lack the necessary cognitive and metacognitive skills, such as monitoring and goal seeking (Sinatra & Pintrich, 2003). Collaborative misconception mapping mediates these skills because the strategy prompts student actions in line with the conceptual change process implicitly through the activity, providing a scaffold to guide students to more meaningful discussions and better learning outcomes, or conceptual/conception change. Using this strategy, students can succeed in reaching a conceptual or conception
change, even if they possess low self-regulatory skills necessary for such a change.

This is so, because they are guided by the collaborative misconception mapping strategy every step of the way, while receiving continuous feedback from informed “expert-peers”, and the tangible instructor-designed concept map. This way, whether students are unable to perform one or more of the first few steps of the intentional conceptual change process, the misconception mapping strategy prompts them to perform another step in the process first. For example, even if students fail to 1) monitor their existing knowledge, 2) locate inconsistent data, or 3) produce goal orientation to learn the material at hand; the collaborative misconception mapping strategy will still bring forth such student actions as 4) solving puzzles through high engagement, 5) comparing rival conceptions, or 6) engaging in critical and thoughtful reflections about concepts and ideas. Thus, once students are involved in any of the latter steps, through feedback from peers and reviewing the misconception map itself, the missing initial steps in the intentional conceptual change process are activated. Students may become 1) able to “self-monitor,” as they compare the clues of their “expert-peers” and the tangible instructor-designed concept map with instructional materials, 2) more attuned to inconsistent data because of their peers’ explanations or search for inconsistencies inherent in the errors on the map, and 3) more intrinsically goal orientated as they search for errors on the map and give hints to peers in a game-like mode.
This process was evident in the findings of this study. Students in the misconception mapping group with low self-regulation levels (step 3 in the intentional conception change process) were not deterred, but rather, they were guided by the strategy's scaffold, and showed evidence of the latter three steps of the intentional conceptual change (more meaningful discussions), and ultimate conception change (better learning outcomes). More specifically, the strategy prompted them to 4) solve puzzles through high engagement, 5) compare rival conceptions, or 6) engage in critical reflections by reflecting thoughtfully about concepts and ideas. Students were able to do this because the strategy, by the nature of its design, always provides prompts to engage in Step 2 of the intentional conceptual change, which requires one to respond to a piece of inconsistent data that leads to dissatisfaction with the existing conception. It is this step that the "displaced" conceptual errors in the misconception map implicitly provide to all students, who then become involved with collaboratively resolving these conflicts, thus displaying intrinsic goal orientation and self-monitoring that was missing from the students' original learning process.

This is reminiscent of what Prawat (2000) described as Vygotsky's intent to provide "bypasses" to "defective" students so that they can function as "normal" students. In other words, the strategy acts as a scaffold to mediate metacognitive skills students lack (p. 671) and fill the gaps in their intentional conceptual change process as well as the discussion process. After all, just because students do not have the skills to produce actions according to the intentional conceptual change process, it does not mean that teachers should abandon
them. Such developmental “maturation” should not have to be the “precondition of learning,” as Vygotsky (1978, p. 80) critiqued Piaget’s view of the relationship between development and learning. Instead, teachers should use scaffolding strategies so that students can become independent and self-regulated (Hartman, 2002), and ready to learn, just as Vygotsky envisioned educational life for students with learning disabilities (Prawat, 2000).

In Vygotsky’s words, “properly organized learning results in mental development” (1978, p. 90). Collaborative learning must then be “properly organized” to promote students’ cognitive and metacognitive processes while focusing on “clearly specified educational goals” (Mayer, 2006, p. 17). If students are guided by a scaffold that mimics the conceptual change process (Sinatra & Pintrich, 2003) and prompts self-regulation, then even those with low self-regulation levels can succeed on learning tasks. As the results of this study showed, such students have the potential to outscore even high self-regulators who participate in unguided learning activities, such as traditional online discussions, when teachers provide implicit scaffolding.

Concluding Thoughts

When students use the collaborative misconception mapping strategy, learning becomes neither purely cognitive as Piaget may have envisioned nor purely social as radical social constructivists believe Vygotsky purported (Koschmann, 2003). Rather, it becomes what Koschmann termed “joint inquiry,” to co-perform a set of operations by which an uncertain situation is resolved (Dewey, 1941, cited in Koschmann, 2003). New knowledge is then not created
outside of one's mental processes as Dewey may have predicted, but rather, meaning-making occurs both cognitively and socially, one informing the other.

Within the realms of the collaborative misconception mapping strategy, students were exploring information, as expected by constructivist theories, and possibly looking at the material with even more critical eyes due to the error hunt function, while guided by the misconception map and the "certain knowledge" inside the correct concept map nodes. Students not only performed better, they also reported lower frustration levels, more certainty, and even some added self-confidence. This is what true social constructivist instructional designers should work towards, rather than leaving students alone in the maze of conceptually unguided online discussions, waiting for their knowledge to independently unfold in a pseudo-Piagetian way, or as the Neo-Piagetian socio-cognitive conflict theorists believe, from social conflict itself (Doise & Mugny, 1984). Not only might students' knowledge not unfold, it may actually be hindered by uncertainties impressed upon them by confused or speechless peers through fruitless discussions. As we have seen from the results of this study, the traditional online discussion question group activity, which could be considered an "unguided exploration" based on anticipated social conflict, resulted in low post-test scores, and fostered more uncertainty, frustration, and lower discussion depth scores.

It is clear that unguided collaborative activities designed to prompt conflict within dyads are not conducive to all students' learning, and that they may actually be detrimental in not only leading to pointless discussions, but also lower levels of engagement with the material at hand, leading to consequent learning
deficiencies. On the other hand, students with low self-regulation levels can benefit from online discussions when they are guided by a strategy like collaborative misconception mapping. This is because the strategy provides an opportunity for students to collaboratively resolve conflict created by an expert-designed-artifact, which also serves as a scaffold that guides dialog and mediates metacognitive student actions, while mimicking the steps of the intentional conceptual change process. This scaffold might be the bridge between social argumentation and learning, two entities whose perceived cause and effect relationship is considered by Koschmann (2003) a dualism that renders socio-cognitive conflict theory problematic. Peer interaction, in the end, is not the cause to cognitive effects, it is simply an avenue, which, if guided appropriately by a knowledgeable teacher-figure and metacognition-enhancing artifact, can steer students towards conceptual change. It is imperative that educators are informed about the benefits of carefully designed strategies and the dangers of student participation in unguided online discussions, as the following section will explain.

Educational Implications

As the Internet revolution takes over higher education worldwide (Cronin & Bachorz, 2005), and the popularity of social constructivist theories’ demands online discussions as some part of course requirements, educators must become aware of the impact students’ discussion board posting experiences have on their learning and perceptions regarding education. Students, if unguided in an
online environment, may “construct knowledge for themselves from interacting with peers” (Salmon, 2004, p. 52), but that knowledge will likely not be at the quality of knowledge preferred by them or by their instructors, unless they are supporters of the idea that students' grades should form a bell-curve.

Some educators are under the impression that simply uploading their syllabus and lecture notes, and requiring participation in unguided online discussions constitutes an online course. It is even promoted by some that the teacher in charge of an online class, who should be trained in appropriately handling online interactions with students, does not truly have to even be a “guru” in the content being learned, because students “construct knowledge for themselves from interacting with peers” (Salmon, 2004, p. 52). This may be true if there are carefully planned and prepared materials and activities or strategies that need only a technical moderator in case of glitches, for example, at the fully online private colleges that have automated courses prepared by a capable instructional design department. However, for traditional universities, where a qualified content expert is in charge of all aspects of a course, information must be disseminated regarding the effects of online discussions, as well as factors that impact aspects of discussion quality and learning outcomes. If educators request online discussions and grade based on number of postings only, then the student who posts a lot of “I agree” responses will receive a higher grade than the student who produces fewer but thought-provoking or content-related posts. This can create disillusionment in students who put a lot of work into their writing. On the other hand, to expect busy educators to read, and rate or respond to every
post appropriately is unrealistic. This is why specific proactive strategies, such as collaborative misconception mapping, need to be devised, where student postings can be objectively critiqued and corrected by an “expert-partner”, such as the one in possession of the corrected nodes on his/her partner’s misconception map. This way, the focus is redirected to the quality, rather than the quantity of student posts.

While some colleges have departments dedicated to the instructional design of all courses and materials, and they utilize e-moderators just to monitor malfunctions online, traditional universities will likely only offer online courses if the instructor in charge of a particular course is willing to design and implement the necessary online materials. Instructors must realize that online discussions are not magic antidotes for the potential negative effects of “blank-slate-forming traditional lectures”, where an expert pinpoints exact information students must learn, rather than expecting them to construct knowledge in some way. Students with low self-regulation levels, who did not succeed in a lecture-type environment, will struggle having to construct their own knowledge, as they do not have the skills or motivation to do so. These students, and even those with desirable levels of metacognitive and cognitive skills, will likely become frustrated and disappointed, and even regress in their learning curve, as can be seen in the results of the current study. That is unless they are provided the necessary objective feedback and metacognition-enhancing or -mimicking tools, such as the collaborative misconception strategy, to help them co-construct appropriate knowledge with their peers. Regrettably, intentional learning is not often
promoted by school activities (Bereiter & Scardamalia, 1989) and explicit self-regulation instruction may not be possible because of time or other constraints. In light of the fact that appropriate learning cannot happen without self-monitoring, educators must be alerted that conceptual change can be induced socioculturally through comprehension activities with the support from peers and led by the teacher (Hatano & Inagaki, 2003), as can be seen in the findings of this study regarding the collaborative misconception mapping strategy.

In addition to the importance of actual positive learning outcomes, students participating in online discussions should be able to expect and perceive that their assignments add to their levels of knowledge, and not just provide “busy-work” to satisfy some course requirement. Students’ time is invaluable. Most of them work at least part-time jobs and take in excess of 12 credits per semester, in addition to worrying about personal and family issues. Requiring participation in online discussions simply because they are allegedly in line with social constructivist theories of learning clearly does disservice to students in not only how these activities contribute to their educational outcome but also how these assignments make them feel. Instructors do not want to require such time-consuming and potentially frustrating activities without scaffolds, if they might, in reality, discourage learning, such as could be seen in the performance of the students with low self-regulation levels after participating in the traditional online discussion activity.

Online discussions, regardless of the tool or strategy used however, may still not be immune to low overall participation rates as students’ non-academic tasks
may steer motivation away from assignment completion (Zimmerman & Bembenutty, 2003). Many students, especially those with low self-regulatory levels may choose not to complete their assignments (Zimmerman & Bembenutty, 2003), or selectively complete only those that make a difference for the grade they would like to achieve, which is often just a grade “C.” Other students may not participate in online discussions because they do not like to interact with their peers, face-to-face or online (Sonnenwald & Li, 2003). Numerous participants in this study had to be reassigned to other students whose partners were also either not responding or posting irresponsibly.

Collaborative activities can be plagued by incompatible partners, in that one is interested in doing a good job and the other is interested in just getting the credit. Unfortunately, it is the one wanting to do a good job who is negatively affected by the neglectful behavior of the other. Especially in dyads, unless the “interested” student is reassigned in time, he or she will also fail to benefit from the online discussion activity. The collaborative misconception mapping activity helps remedy this to some extant, as standard hints and responses regarding the errors, their corrections and references to helpful sources can be quickly provided by the instructor when reassignment is not possible. The same might not be as easy to resolve with traditional discussions, as the instructor has to sift through students’ often lengthy initial posts, similarly to correcting responses to open-ended questions on an exam.

Designing misconception maps, however, may be too taxing for instructors, who may not have the time, patience, or desire to prepare such maps for each
content area. It is also much quicker to simply count the number of responses posted by students, and give scores based on level of participation according to the quantity rather than the quality of posts (Spatariu, Hartley, & Bendixen, 2004). However, if instructors’ true interest lies in the sharpening of students’ knowledge, then time investment in such tools should not be an inconvenience. If students with certain characteristics, such as low self-regulation, are actually negatively affected by participating in traditional online discussions, then it is instructors’ responsibility to prepare tools to reach these students. After all, students with high self-regulatory skills will likely learn new material all by themselves, without any help from their instructors. It is those students unable to learn by themselves that need the guidance, facilitation or scaffolding from their teachers. The investment in the preparation of a misconception map would pay off in better student outcomes as well as time and effort saved when evaluating student discussions, as they tend to be more structured and less rambling than posts of students participating in traditional online discussion activities.

Limitations

While the findings were intriguing and thought-provoking, the sample size was possibly not adequate to draw appropriate conclusions about the effectiveness of collaborative misconception mapping. The small sample size as well as the narrow topics in statistics used for this study does not allow for generalization of findings to all college students. It is promising, however, to see that discussions were more meaningful and post-test scores higher despite the highly technical
nature of the topic of statistics, which may not otherwise promote student engagement. Other issues that may have hindered the accuracy of the study results were that students were discouraged by the long assessments and were possibly not warned adequately about the value of their input or the deadline, as the researcher was not able to meet with them face-to-face. Students seemed to be very late in posting on the discussion board, negatively influencing the performance of those who were on time. Students also had limited experience with the system used (WebCampus), and should have been trained in the use of the discussion board. Unfortunately, time-constraints and physical distance did not allow for training in addition to the written instructions all subjects were provided. This may have affected the collaborative misconception mapping group more, due to the novelty of concept mapping and error hunting activities; while the morale of the traditional discussion question group may have been lowered due to subjects' exclusion from this novel activity.

Also due to lack of adequate training, one of the shortfalls of the misconception mapping activity was that sometimes students got stuck directing each other to the “bubbles” that needed to be corrected, even in an error-hunt-treasure-hunt fun way, rather than talking about actual content. Students had only one opportunity to practice this new strategy, without any feedback from the researcher regarding the quality of their participation due to insufficient time elapse between the two studies. This would, however, not be a problem for instructors who get to interact with their students in person to practice the strategy. The strategy could also be altered to encourage less discussion about
“bubbles,” by marking the error bubbles, making only error-correction the task, rather than error hunt and correction. However, students may not review the entire map and just focus on the marked flawed bubbles, thus not benefiting from the entirety of the concept map. This would be similar to traditional discussion questions that narrowly focus on one or two aspects of the content, depriving students of the opportunities to explore the material more extensively.

Future Studies

Future studies can investigate whether students’ perceptions would be better if the locations of at least some of the errors are provided, so that they can start researching the corrections immediately, while they await the response from their partners. Another issue with the misconception mapping discussions that needs attention is the fact that when students find their errors by themselves before participating on the board, they are left with nothing to discuss. It is similar to the traditional discussion partners answering “I agree”. This could be resolved by including more than two errors to raise the probability of need for clarification of some content. It would also be important to research whether the mere act of individually reviewing the misconception map and searching for the errors without a partner can contribute to similarly increased knowledge. A study of face-to-face discussion groups versus individual error hunting groups actually showed such results (Sas, Nussbaum & Sas, 2005). In this study, undergraduate students who individually reviewed misconception maps and corrected errors had similar post-test performances as those who participated in face-to-face discussions about
the same errors. Individual students were given the corrected map at the end of the study as feedback, which means that they may have simply benefited from the review of the concept map. It would be interesting to test whether students would gain equally from online discussions and individual error hunting/verifying assignments.

Comparing the learning outcomes of low and high self-regulators further, including other interactions, such as effort-regulation levels, or critical thinking may also be beneficial. It would also be worth studying if the course-specific self-regulation levels of students are affected by the collaborative misconception mapping strategy use itself. In addition, this strategy should be compared to other tools, such as sentence openers and note starters. Cognitive load issues regarding the collaborative misconception mapping strategy could also be investigated.

On a larger scale it would be interesting to survey university professors regarding their use of online discussions as part of course requirements, such as, what exactly is requested of the students, what kind of scaffolding is provided and what criteria are being used to rate participation. Do professors mainly count the number of postings? Are they aware of the impact online discussions may have on their students' development? Similarly, students should be surveyed regarding their experience with online discussions. Do they feel they benefit from them? What do their professors use to rate their level of participation? Would they rather perform face-to-face collaborative or individual online activities?
Answers to such questions could shed some light on the trends in online education, and the areas that need research, development and training.

Conclusion

Collaborative misconception mapping, a knowledge building strategy (Bereiter, 2002), is a learning scaffold centered around finding and correcting common misconceptions on a concept map, with the help of an online partner. In this strategy, students build a “cognitive artifact” online, or a collection of ideas and thoughts, through the processes of scientific engagement promoted by Alexopoulou and Driver (1996), Brown and Palincsar (1989), Chan (2001) and Lampert and Cobb (2003), more specifically, the formulation or clarification of ideas, justifications, reflections and search for new information, and recognition of inconsistencies, formulation of questions and co-construction of explanations. This strategy embraces the importance of cognitive and metacognitive skills, theories of self-regulation as well as the Questioning the Author approach (Beck & McKeown, 2001), to promote scientific inquiry through concept organization, planning, monitoring and regulated learning, while mimicking the intentional conceptual change process during online discussions.

The misconception map provides students with the opportunity to evaluate connections among potentially abstract concepts on a tangible medium, and brings about the collaborative exploration of conflicting information, allowing students to gradually integrate and monitor their developing knowledge and comprehension with well-informed feedback from their peers. Collaboratively
solving the puzzle of the errors on the map with fellow students, and displacing their conflict onto a task rather than each other may further promote meaningful argumentation. This kind of strategy promises to create the “conflicting yet collaborative” environment that research shows may lead to better learning outcomes in the areas of science than ordinary student discussions, where students’ mostly repeat or reject what others have said (Alexopoulou & Driver, 1996; Chan, 2001).

In effect, collaborative misconception mapping offers indirect instructor facilitation via the concept map clues, peer feedback via the error hunt and verification, and monitoring of individual knowledge level and quality via the interactions and the visual representation of the concept map at hand. In contrast, in traditional discussion question based online discussions, students do not generally receive feedback from their instructors due to time constraints, and may receive incomplete or inaccurate feedback from their peers depending on their levels of knowledge or content-uncertainty. The misconception mapping strategy, on the other hand, allows for the much needed “metacognitive guidance,” which is known to “have positive effects on students’ mathematical reasoning in cooperative learning” (Kramarski & Mizrachi, 2006, p. 218.). Without such metacognitive guidance, online discussion alone may not be sufficient to enhance student knowledge (Kramarski & Mizrachi, 2006).

The collaborative misconception mapping prompts metacognitive student behaviors, thus enhancing the meaningfulness of discussions, and ultimately improving learning outcomes, even for those with individual characteristics
unfavorable to online collaborative environments, such as low self-regulation and preference for individual assignments. This kind of strategy is especially important in an online environment, where students are generally expected to be more independent and motivated to read, process and participate in online discussions without personal instructor supervision. Because of this expectation, instructors may simply require students to post answers to discussion questions, which means that if students are not independent or metacognitively skilled enough, they will fail to benefit from the supposed social constructivist learning environment.

Such requirements indicate misinterpretations or a disregard for Vygotsky’s sociocultural theory, which promotes that educators supply scaffolding strategies so that students can become independent and self-regulated (Hartman, 2002) if those characteristics are lacking. If instructors fail to provide scaffolds to facilitate meaningful student discussions that are centered around the learning of course-related concepts, while mediating or guiding self-regulatory behavior and providing accurate feedback, then the pseudo social constructivist environment created by hazy online forums becomes not only immaterial but possibly a detriment to students’ attitudes and course-related performance. This is especially disquieting considering the continuous explosion of online education, as well as traditional instructors’ use of online discussions in place of conventional assignments, in their attempt to fit in with the 21st century educational fads.
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Measurements.


Educational Research Association (Chicago, IL, April 21-22). ERIC reproduction number ED 477 449.
Table 1

Demographic Information

<table>
<thead>
<tr>
<th></th>
<th>CMM (n=24)</th>
<th>TDQ (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>22.3</td>
<td>24.5</td>
</tr>
<tr>
<td>GPA</td>
<td>3.39</td>
<td>3.41</td>
</tr>
<tr>
<td>Hours Worked</td>
<td>25.2</td>
<td>20.8</td>
</tr>
<tr>
<td># of Credits</td>
<td>12.7</td>
<td>14.2</td>
</tr>
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</table>

Gender Percentages

Male 12.5 31.0
Female 87.5 69.0

Ethnicity Percentages

African American 4.2 13.7
Asian 4.2 3.4
Asian/Pacific Islander 8.3 10.3
Caucasian 50.0 51.7
Filipino 20.8 10.3
Other 8.4 6.9

CMM = Collaborative Misconception Mapping group
TDQ = Traditional Discussion Question group
Table 2

*Item Analysis Statistics*

<table>
<thead>
<tr>
<th>Question #</th>
<th>Difficulty</th>
<th>Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.19</td>
<td>52.94</td>
</tr>
<tr>
<td>2</td>
<td>80.60</td>
<td>47.06</td>
</tr>
<tr>
<td>3</td>
<td>32.84</td>
<td>70.59</td>
</tr>
<tr>
<td>4</td>
<td>82.09</td>
<td>17.65</td>
</tr>
<tr>
<td>5</td>
<td>41.79</td>
<td>76.47</td>
</tr>
<tr>
<td>6</td>
<td>89.55</td>
<td>23.53</td>
</tr>
<tr>
<td>7</td>
<td>80.60</td>
<td>41.18</td>
</tr>
<tr>
<td>8</td>
<td>79.10</td>
<td>35.29</td>
</tr>
<tr>
<td>9</td>
<td>50.75</td>
<td>82.35</td>
</tr>
<tr>
<td>10</td>
<td>53.73</td>
<td>88.24</td>
</tr>
</tbody>
</table>
Table 3  
*Estimated Marginal Mean*⁹ Post-test Scores and Standard Errors for CMM and TDQ Participants by Self-regulation Levels

<table>
<thead>
<tr>
<th></th>
<th>CMM</th>
<th>TDQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Self-regulators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>M</td>
<td>19.58</td>
<td>15.99</td>
</tr>
<tr>
<td>SE</td>
<td>.887</td>
<td>.993</td>
</tr>
<tr>
<td><strong>High Self-regulators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>M</td>
<td>19.41</td>
<td>18.25</td>
</tr>
<tr>
<td>SE</td>
<td>.924</td>
<td>.724</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td>Mean</td>
<td>19.49</td>
<td>17.12</td>
</tr>
<tr>
<td>SE</td>
<td>.639</td>
<td>.587</td>
</tr>
</tbody>
</table>

⁹ Evaluated at covariate ‘pre-test scores’.
Table 4

ANCOVA Statistics for Comparison of Post-test Scores of CMM and TDQ Participants with Low and High Self-regulation Levels

<table>
<thead>
<tr>
<th></th>
<th>Mean Difference</th>
<th>Sum of Squares</th>
<th>F(1,47)</th>
<th>Sig</th>
<th>Eta Sq.</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1.95</td>
<td>70.03</td>
<td>7.48</td>
<td>.009</td>
<td>.137</td>
<td>.764</td>
</tr>
<tr>
<td>SR Rating</td>
<td>13.61</td>
<td>1.45</td>
<td>.030</td>
<td>.219</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>17.86</td>
<td>1.90</td>
<td>.039</td>
<td>.272</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Covariate: Pre-test scores.
Table 5

Pre- and Post-test Means and standard deviations for CMM and TDQ by Self-Regulation (SR) Levels

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>Pre-test SD</th>
<th>Mean</th>
<th>Post-test SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CMM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SR (n=12)</td>
<td>15.37</td>
<td>3.00</td>
<td>19.20</td>
<td>2.76</td>
</tr>
<tr>
<td>High SR (n=11)</td>
<td>16.80</td>
<td>3.39</td>
<td>19.85</td>
<td>3.19</td>
</tr>
<tr>
<td>Total (n=23)</td>
<td>16.02</td>
<td>3.19</td>
<td>19.50</td>
<td>2.91</td>
</tr>
<tr>
<td><strong>TDQ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SR (n=11)</td>
<td>16.55</td>
<td>5.46</td>
<td>16.16</td>
<td>5.16</td>
</tr>
<tr>
<td>High SR (n=18)</td>
<td>15.17</td>
<td>3.62</td>
<td>17.91</td>
<td>3.64</td>
</tr>
<tr>
<td>Total (n=29)</td>
<td>15.65</td>
<td>4.29</td>
<td>17.30</td>
<td>4.21</td>
</tr>
</tbody>
</table>
### Table 6

*Repeated Measure ANCOVA Statistics for Pre and Post-test Score Comparisons of CMM and TDQ Groups by Self-Regulation (SR) Levels*

<table>
<thead>
<tr>
<th>Effects</th>
<th>Sum of Squares</th>
<th>$F_{(1,43)}$</th>
<th>Sig</th>
<th>$\eta^2$ Sq.</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>28.94</td>
<td>4.35</td>
<td>.043</td>
<td>.092</td>
<td>.532</td>
</tr>
<tr>
<td>Group * SR</td>
<td>21.29</td>
<td>3.20</td>
<td>.080</td>
<td>.069</td>
<td>.417</td>
</tr>
</tbody>
</table>

Covariate: GPA
Table 7

*Mean CMM and TDQ Discussion Depth Scores and Standard Deviations*

<table>
<thead>
<tr>
<th></th>
<th>CMM (n=16)</th>
<th>TDQ (n=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>2.75</td>
<td>.57</td>
</tr>
<tr>
<td>Mean</td>
<td>3.31</td>
<td>1.12</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8

GLM ANOVA Statistics for Comparison of Discussion Scores of CMM and TDQ Participants

<table>
<thead>
<tr>
<th>Mean Difference</th>
<th>Sum of Squares</th>
<th>$F(1, 35)$</th>
<th>Sig</th>
<th>Eta Sq</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.18</td>
<td>43.1</td>
<td>7.93</td>
<td>.008</td>
<td>.185</td>
<td>.782</td>
</tr>
</tbody>
</table>
Figure 1. Example of a concept map and corresponding misconception map.

Concept Map

Misconception Map

The misconception map indicates that cats have 2 tails and that dogs have 6 legs, and that cats chase dogs and dogs run away from cats.
Figure 2. Visual representation of the parallel between the collaborative misconception mapping strategy and the intentional conceptual change model.

This framework is based on the steps of the intentional conceptual change process described by Sinatra and Pintrich (2003).
Figure 3. Graphical Representation of Estimated Marginal Mean Post-test Scores of Low and High Self-regulators in the CMM and TDQ Treatment Groups.
Figure 4. Graphical Representation of Pre-test to Post-test Score Changes of Low and High Self-regulators in the CMM and TDQ Treatment Groups.
Figure 5. Framework of the CMM strategy’s theoretical implications

Online Discussions
- inadequate/fruitless collaboration
- low levels of learning outcome
- decreased learner satisfaction
(Hallett & Cummerse, 1997; Krijsns, Kirschner, & Jochems, 2002)

due to

- individualistic learning preferences (Sommerwill & Li, 2003) & unfavorable cognitive/emotional student characteristics (Nussbaum et al., 2002)
- wrong kind of argumentation being fostered (Koschmann, 2003)
- lack of appropriate scaffolding (Andriessen et al., 2003)
- wrong kind of argumentation being fostered (Koschmann, 2003)

1) Internal conflict instead of disagreement
2) Critique of fallible authority (Beck & McKeown, 2001) instead of each other

However

Internal conflict alone is not enough to initiate intentional conceptual change process (Sinha & Perlech, 2003)

Scaffolded (Vygotsky, 1970) sociocultural comprehension activities to induce intentional conceptual change (Hatano & Inagaki, 2003)

Generation of explanation, justifications, reflection and a search for new information (Brown & Palincsar, 1989)

Recognition of problems (or inconsistencies), formulation of questions and co-construction of explanations (Alexopoulos & Driver, 1996; Chan, 2001)

Formulation or clarification of ideas (Lampert & Cobb, 2003)

Self-regulation (Zimmerman, 1994; Mediation (Prawat, 2000)
1) guide goal setting
2) promote reflective dialogue
3) provide corrective feedback
4) connect abstract concepts (Travers and Breckley, 2000)

CMM: expert-designed artifact-mediated scaffold allows for displaced co-critique of fallible authority and metacognitive guidance

Results: increased learning, more meaningful discussions, learner satisfaction even for students with low self-regulation and low intrinsic motivation levels, or those with preference for individual assignments

125
Pre-test (Correlation Assignment)

1. (Points: 0)
Those students who scored lower on their final exams tended to also be the ones who studied less throughout the semester. This example might represent

- a. Positive correlation
- b. Negative correlation
- c. Zero correlation

Save Answer

2. (Points: 0)
Most patients who reported drinking more tap water had a higher number of reported kidney stones. This might be an example of

- a. Positive correlation
- b. Negative correlation
- c. Zero correlation

Save Answer
3. (Points: 0)
Zero correlation indicates that

☐ a. there is a lack of significant difference between two groups of subjects.

☐ b. there is no relationship between two variables for a group of subjects.

☐ c. higher scores on one variable go with lower scores on the other.

☐ d. lower scores on one variable go with lower scores on the other.

Save Answer

4. (Points: 0)
Some children who used more colors when drawing had higher art grades while other children who used more colors had lower art grades. This might be an example of

☐ a. Positive correlation

☐ b. Negative correlation

☐ c. Zero correlation

Save Answer

5. (Points: 0)
Which of the following CANNOT be a correlation number?

☐ a. -.8

☐ b. +2.5

☐ c. -.1

Save Answer
6. (Points: 0)
Students with longer hair spent less money on hair products. This might be an example of

☐ a. Positive correlation
☐ b. Negative correlation
☐ c. Zero correlation

Save Answer

7. (Points: 0)
Negative correlation indicates that

☐ a. there is a lack of significant difference between two groups of subjects.
☐ b. there is no relationship between two variables for a group of subjects.
☐ c. higher scores on one variable go with lower scores on the other.
☐ d. lower scores on one variable go with lower scores on the other.

Save Answer

8. (Points: 0)
Please provide a scenario that describes data that might produce a negative correlation. Please provide two examples of how subjects may score on the variable(s) in question.
9. (Points: 0)
Please provide a scenario that describes data that might produce a positive correlation. Please provide two examples of how subjects may score on the variable(s) in question.

10. (Points: 0)
Please provide a scenario that describes data that might produce a zero correlation. Please provide two examples of how subjects may score on the variable(s) in question.

11. (Points: 0)
How would you explain a strong negative correlation between "number of microwaved meals per day" and "blood pressure levels"?
Demographics & MSLQ Questionnaire

Instructions
Please do your best on this test. The results will NOT count toward your grade (even if you don't know the answers, it's ok), but your performance will affect my study results.

1. (Points: 0)
I have received an electronic copy of the informed consent form; typing 'yes' below serves as my consent to participate in this study.

2. (Points: 0)
What is your gender?

3. (Points: 0)
What is your age (or age range)?

4. (Points: 0)
What is your grade level?
5. (Points: 0)
What is your major?

1.

Save Answer

6. (Points: 0)
What is your ethnic background?

1.

Save Answer

7. (Points: 0)
Is English your second language?

1.

Save Answer

8. (Points: 0)
What is your GPA?

1.

Save Answer

9. (Points: 0)
How many hours do you work per week?

1.

Save Answer
10. (Points: 0)
How many credits are you taking this semester?

1.

Save Answer

11. (Points: 0)
How confident are you using WebCT?

1.

Save Answer

12. (Points: 0)
How confident do you feel working with numbers?

1.

Save Answer

13. (Points: 0)
1. In class, I prefer course material that really challenges me so I can learn new things.

1.

Save Answer
14. (Points: 0)
In class, I prefer course material that arouses my curiosity, even if it is difficult to learn.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer

15. (Points: 0)
The most satisfying thing for me in this class is trying to understand the content as thoroughly as possible.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer

16. (Points: 0)
When I have the opportunity in class, I choose course assignments that I can learn from, even if they don't guarantee a good grade.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer

17. (Points: 0)
During class time, I often miss important points because I'm thinking of other things.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer
18. (Points: 0)
When reading for this class, I make up questions to help focus my reading.

Not at all true of me 1 2 3 4 5 6 Very true of me

1. 

Save Answer

19. (Points: 0)
When I become confused about something I'm reading in class, I go back and try to figure it out.

Not at all true of me 1 2 3 4 5 6 Very true of me

1. 

Save Answer

20. (Points: 0)
If class readings are difficult to understand, I change the way I read the material.

Not at all true of me 1 2 3 4 5 6 Very true of me

1. 

Save Answer
21. (Points: 0)
Before I study new course material thoroughly, I often skim it to see how it is organized.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.  

Save Answer

22. (Points: 0)
I ask myself questions to make sure I understand the materials I have been studying in class.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.  

Save Answer

23. (Points: 0)
I try to change the way I study in order to fit the course requirements and the instructor's teaching style.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.  

Save Answer
24.  
(Point: 0)  
I often find that I have been reading for this class but don't know what it was all about.  

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

25.  
(Point: 0)  
I try to think through a topic to decide what I am supposed to learn from it rather than just reading it over when studying for this class.  

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

26.  
(Point: 0)  
When studying for this class I try to determine which concepts I don't understand well.  

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

27.  
(Point: 0)  
When I study for class, I set goals for myself in order to direct my activities in each study period.  

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.
28.  
(Point: 0)  
If I get confused taking notes in class, I make sure I sort it out afterwards.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer

29.  
(Point: 0)  
I often find myself questioning things I hear or read in this class to decide if I find them convincing.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer

30.  
(Point: 0)  
When a theory, interpretation or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.

Not at all true of me 1 2 3 4 5 6 Very true of me

1.

Save Answer
31.
(Point: 0)
I treat course material as a starting point and try to develop my own ideas about it.

32.
(Point: 0)
I try to play around with ideas of my own related to what I am learning in this class.

33.
(Point: 0)
Whenever I read or hear an assertion or conclusion in class, I think about possible alternatives.

34.
(Point: 0)
When I study for a class, I pull together information from different sources, such as lectures, readings and discussions.
35. (Points: 0)
I try to relate ideas from one course to those in other courses whenever possible.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

36. (Points: 0)
When reading for class, I try to relate the material to what I already know.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

37. (Points: 0)
When I study for a course, I write brief summaries of the main ideas from the readings and my class notes.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer
38. (Points: 0)
I try to understand the material in class by making connections between the readings and the concepts from the lectures.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

39. (Points: 0)
I try to apply ideas from course readings in other class activities such as lecture and discussion.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

40. (Points: 0)
When I study the readings for this class, I outline the material to help me organize my thoughts.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer
41. (Points: 0) When I study for this class, I go through the readings and my class notes and try to find the most important ideas.

42. (Points: 0) I make simple charts, diagrams, or tables to help me organize course material.

43. (Points: 0) When I study for a course, I go over my class notes and make an outline of important concepts.

44. (Points: 0) Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.
45. (Points: 0)
I ask the instructor to clarify concepts I don't understand well.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

46. (Points: 0)
When I can't understand the material in a course, I ask another student in class for help.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer

47. (Points: 0)
I try to identify students in class whom I can ask for help if necessary.

Not at all true of me 1 2 3 4 5 6 7 Very true of me

1.

Save Answer
48.  
(Points: 0)  
When studying for this class I often try to explain the material to a classmate or friend.  

Not at all true of me  
1 2 3 4 5 6 7  
Very true of me  

1.  

Save Answer  

49.  
(Points: 0)  
I try to work with other students from this class to complete the course assignments.  

Not at all true of me  
1 2 3 4 5 6 7  
Very true of me  

1.  

Save Answer  

50.  
(Points: 0)  
When studying for this class, I often set aside time to discuss course material with a group of students from the class.  

Not at all true of me  
1 2 3 4 5 6 7  
Very true of me  

1.  

Save Answer
Post-test (Correlation Assignment)

1. (Points: 0)
Those students who scored lower on their final exams tended to also be the ones who studied less throughout the semester. This example might represent

☐ a. Positive correlation
☐ b. Negative correlation
☐ c. Zero correlation

Save Answer

2. (Points: 0)
Most patients who reported drinking more tap water had a higher number of reported kidney stones. This might be an example of

☐ a. Positive correlation
☐ b. Negative correlation
☐ c. Zero correlation

Save Answer

3. (Points: 0)
Zero correlation indicates that

☐ a. there is a lack of significant difference between two groups of subjects.
☐ b. there is no relationship between two variables for a group of subjects.
☐ c. higher scores on one variable go with lower scores on the other.
☐ d. lower scores on one variable go with lower scores on the other.

Save Answer
4. (Points: 0)
Some children who used more colors when drawing had higher art grades while other children who used more colors had lower art grades. This might be an example of

- a. Positive correlation
- b. Negative correlation
- c. Zero correlation

Save Answer

5. (Points: 0)
Which of the following CANNOT be a correlation number?

- a. -.8
- b. +2.5
- c. -.1
- d. +.7

Save Answer

6. (Points: 0)
Students with longer hair spent less money on hair products. This might be an example of

- a. Positive correlation
- b. Negative correlation
- c. Zero correlation

Save Answer
7. (Points: 0)
Negative correlation indicates that

☐ a. there is a lack of significant difference between two groups of subjects.

☐ b. there is no relationship between two variables for a group of subjects.

☐ c. higher scores on one variable go with lower scores on the other.

☐ d. lower scores on one variable go with lower scores on the other.

Save Answer

8. (Points: 0)
Please provide a scenario that describes data that might produce a negative correlation. Please provide two examples of how subjects may score on the variable(s) in question.

Paragraph

Save Answer

9. (Points: 0)
Please provide a scenario that describes data that might produce a positive correlation. Please provide two examples of how subjects may score on the variable(s) in question.

Paragraph

Save Answer
10. (Points: 0)
Please provide a scenario that describes data that might produce a zero correlation. Please provide two examples of how subjects may score on the variable(s) in question.

Paragraph

Save Answer

11. (Points: 0)
How would you explain a strong negative correlation between "number of microwaved meals per day" and "blood pressure levels"?

Paragraph

Save Answer

12. (Points: 0)
How much time did you spend on the activity, not including the time it took you to take the two quizzes? (Please indicate whether you are using hours or minutes)

1.

Save Answer

13. (Points: 0)
What sources did you use to complete this activity? (e.g.: handouts, books, etc.)

1.

Save Answer
14.  
(Points: 0)
Did this activity enhance your knowledge?

☐ a. not at all

☐ b. somewhat

☐ c. very much

Save Answer

15.  
(Points: 0)
Did this activity cause you to be frustrated?

☐ a. not at all

☐ b. somewhat, but it was worth it

☐ c. somewhat, and it interfered with learning

☐ d. very much, but it was worth it

☐ e. very much, and it interfered with learning

Save Answer

16.  
(Points: 0)
Did you find this activity mentally challenging (did you have to think hard)?

☐ a. not at all, I didn't really have to think much

☐ b. somewhat, but I liked it

☐ c. somewhat, and it was annoying

☐ d. very much so, but I liked it

☐ e. very much so, and it was very annoying
17. (Points: 0)
How well did this assignment help you to see how much of the material (correlation) you really understood and where you still needed help? Please elaborate :-)

Paragraph

Save Answer

18. (Points: 0)
How well did this assignment contribute to your reading your textbook/handouts or other related reading materials? Please elaborate.

Paragraph

19. (Points: 0)
What did you like most about this activity?

Paragraph

20. (Points: 0)
What did you like least about this activity?
21. (Points: 0)
Would you participate in similar activities in the future?

☐ a. Yes
☐ b. No
☐ c. Yes, if activity was improved

Save Answer

22. (Points: 0)
Would you have rather done a different assignment?

☐ a. yes
☐ b. no
☐ c. can't decide

Save Answer

23. (Points: 0)
How would you improve this activity for the future? Please share any comments you may have.

[Paragraph]

Save Answer
APPENDIX B

INSTRUCTIONS AND MATERIALS

FOR THE TWO ACTIVITIES

Instructions for the Collaborative Misconception Mapping Activity

- In the Concept Map attachment in your email there is a concept map that contains 2 errors.
- You have a discussion partner, whose map contains 2 different errors.
- You know where your partner’s errors are because the two locations are marked on your map (thicker bubbles).
- The locations of your errors are marked on your partner’s map.
- It’s like a game: without giving out the actual correct answers, one of your tasks is to guide your partner in finding and correcting his or her map’s errors (if your partner asks for help!).
- In the mean time, you try to find and correct two different errors on your map with your partner’s help, if needed.
- Please quote your textbook or an online source when providing hints and when explaining your corrections!!

What I mean by hints:
For example: when your partner asks for your help, you should say “look on page XYZ in our book” or “look at this website...”, “where it’s talking about ....” instead of “go left on your map and up”. If your original hint does not work, you can tell them exactly where the error is, but don’t give them the correction, only where they might be able to find information to correct the errors. You are in a way tutoring your partner through this “game” – the GOAL IS LEARNING and not necessarily getting the right answer as quickly as possible!!

Your performance on this assignment depends on your participation in the discussions, and NOT on the results of the pre- or post-tests. Do your best on the tests though, so that my study can be accurate!! Thanks!
EXACT STEPS TO FOLLOW FOR THIS ASSIGNMENT:

1. **BEFORE YOU EVEN LOOK AT THE CONCEPT MAP: TAKE the PRE-TEST** under the Assessments icon in WebCampus; it’s entitled “Step 1 - Pre-test Correlation Assignment”.

2. **Review your Concept Map and search for the two errors** (grammatical ones don’t count!); take your time, follow the arrows, starting from the top left – you can print the map if you’d like.

3. In the Discussion Board entitled “Correlation”, **START TWO SEPARATE DISCUSSIONS (one for each of your errors)**. State what the error is and what the correction might be; quote your notes, textbook, or some other outside source. Your partner will tell you if you are on the right track.

4. **If you can’t find an error, post “Help Please”** so your partner knows you need a hint.

5. The two thicker bubbles on your map pinpoint the exact **location of your partner’s errors**. Please remember, these two bubbles contain the correct information on your map, this is how you can help your partner with his/her error hunt. Do not give away the actual answers, rather, guide your partner in finding their errors as best as you can by referring them to a source (class notes, text book page number, internet address, etc.), so that he/she can do the “thinking” and actual correction.

6. **Respond to your partner’s postings until all errors are located, corrected and explained.**

7. When you feel you have discussed all the errors and provided explanations to your partners as necessary, make a decision as a team that it’s time to **TAKE the POST-TEST (individually)**, which is under the Assessments icon; it’s entitled “Last Step - Post-test Correlation Assignment”.

8. **PLEASE DO NOT DISCUSS THE MAPS IN PERSON; IT WILL AFFECT THE STUDY RESULTS.**

9. **PLEASE RESPOND TO YOUR PARTNER’S POSTINGS PROMPTLY TO AVOID DELAYS IN HIS/HER AND YOUR LEARNING!**

10. **Email me or call me (319-389-3314) if your partner isn’t responding to you so I can reassign you.**
Instructions for the Traditional Discussion Question Activity

Some of your classmates are working on a similar assignment, which requires them to review a concept map before they begin their online discussions. In case you are wondering, YOU ARE NOT RECEIVING A CONCEPT MAP THIS TIME (nothing against you, just random selection for the study... lol). Instead, you will be discussing four questions regarding correlation with a partner in WebCampus; you will initiate two discussions and your partner will also initiate two discussions. Please quote your textbook or an online source when explaining your answers or responses.

STEP BY STEP INSTRUCTIONS:

11. **TAKE the PRE-TEST** under the Assessments icon in WebCampus; it’s entitled “Step 1 – Pre-test Correlation” **PLEASE** do NOT look at the discussion questions before you take the pre-test.
12. Review your discussion questions in the Discussion Questions attachment.
13. In the Discussion Board entitled “Correlation”, **START TWO SEPARATE DISCUSSIONS (one for each of your questions)**. Make sure you include the actual discussion question in the posting, because your partner needs to know what you are responding to. Be sure to quote your textbook or other Internet source.
14. Your partner has two different discussion questions, to which they are to post initial responses on the discussion board. **Respond to your partner’s postings at least four times**.
15. When you feel you have discussed all issues successfully, make a decision as a team that it’s time to **TAKE the POST-TEST** (individually), which is under the Assessments icon; it’s entitled “Last Step – Post-test Correlation”

IMPORTANT:

While the pre- and post-test results are important to me (the researcher), it is the PROCESS of discussing the issues and looking up information for yourself or for your partner that matters most to you (the participant). In other words, your performance on this assignment depends on your participation in the discussions, and NOT on the results of the pre- or post-test. Do your best, though, to ensure that my study results are accurate!

The GOAL IS LEARNING and not necessarily getting the right answer as quickly as possible!!
PLEASE DO NOT DISCUSS THE ASSIGNMENT IN PERSON; IT WILL AFFECT THE STUDY RESULTS.

PLEASE RESPOND TO YOUR PARTNER'S POSTINGS PROMPTLY TO AVOID DELAYS IN HIS/HER AND YOUR LEARNING!

Email me or call me on my cell (319-389-3314) in case your partner is not responding. I'll reassign you if I can!
CORRELATION

-1 (negative one)
to +1 (positive one)

-1 indicates a strong negative relationship
0 indicates no relationship
+1 indicates a strong positive relationship

The strength of the relationship can be indicated by the magnitude of the correlation coefficient.

Subjects tend to receive low scores on one variable but high scores on the other. OR high scores on one variable but low scores on the other.

A likely example of this might be:
- Students' GPAs and number of parties attended

- Students with low GPAs tend to have lower parties attendance
- Students with high GPAs tend to have more parties attended

A likely example of this might be:
- Students' GPAs and hours studying

- Students with high GPAs tend to study more
- Students with low GPAs tend to study less

- No pattern of relationship between the scores on the two variables
Below are the two discussion questions that you need to respond to on the “Correlation ...” discussion board. Please copy and paste the question along with your response, so that your partner can see what you are discussing. Once your partner posts his/her responses to their two questions, make sure you comment on those posts.

1. How would you describe data that show a strong negative correlation between “minutes spent on mobile phone calls while driving” and “number of traffic accidents”? (You should include two examples, such as, “a person who makes a lot of phone calls has .... accidents while the person who makes few phone calls has .... accidents.”) How would mobile phone companies explain such a phenomenon? How would you explain such a phenomenon?

2. If researchers found that there is a strong positive correlation between “number of caffeinated drinks consumed per day” and “intelligence scores”, what would the makers of such drinks be able to legally claim? What would they like to have the general population believe? What do YOU think such a phenomenon could mean?
Discussion Questions – Partner 2

Below are the two discussion questions that you need to respond to on the “Correlation ...” discussion board. Please copy and paste the question along with your response, so that your partner can see what you are discussing. Once your partner posts his/her responses to their two questions, make sure you comment on those posts.

1. How would you describe data that show a zero correlation between “number of minutes in the gym” and “waist size in inches”? (You should include two examples, such as, “a person who spends a lot of time in the gym has .... waist size and the person who spends little time at the gym has .... waist size.”) How would the owners of health clubs like to explain such a phenomenon? How would YOU explain such a phenomenon?

2. How is it different to 1) run a correlational study to analyze the relationship between “sugar consumption” and “cholesterol levels” and 2) compare the cholesterol levels of two groups of people after administering high versus low sugar doses? What would a positive correlation mean?
CHECKLIST FOR EVALUATING DISCUSSIONS

Award 2 points each except 4a, 6b & 7b

1. expression of intrinsic goal orientation (learning or performance oriented)
2. realization of own level of understanding and/or need for more information
3. asking for location of source or clarification/corrective feedback
4. collaborative explanation/elaboration on the meaning of concepts and relationships among them
   c. referring to evidence from course material (3 points)
   d. not referring to course material
5. pointing out peer's level of understanding and/or providing location of source or clarification/corrective feedback
6. accepting conceptual critique and/or correction by peer – mini conceptual change or conception change
   a. by agreeing
   b. by elaborating (3 points)
7. questioning conceptual critique and/or correction by peer (leading back to point 4 above)
a. by simply disagreeing (1 point)

b. by elaborating (3 points)

8. referring to instructional material
VITA

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