

The Pennsylvania State University  
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**EFFECTS OF PEER-CONTROLLED OR EXTERNALLY STRUCTURED AND  
MODERATED ONLINE COLLABORATION ON GROUP PROBLEM SOLVING  
PROCESSES AND RELATED INDIVIDUAL ATTITUDES IN WELL-  
STRUCTURED AND ILL-STRUCTURED SMALL GROUP PROBLEM  
SOLVING IN A HYBRID COURSE**

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Instructional Systems

by

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## ABSTRACT

The primary purpose of the study is to investigate the relative effects of two approaches to peer online collaboration (peer-controlled and externally structured and moderated) on the group problem solving processes during well-structured and ill-structured problem solving tasks. The secondary purpose is to examine the effects of the two approaches on individual learners' related attitudes.

Vygotsky (1978) states that social interactions play a very important role in learning and recent research demonstrates that working in small groups facilitates learning (Johnson & Johnson, 1975; Hamm & Adams, 1992; Bosworth & Hamilton, 1994; Bruffee, 1999). As a result, collaborative learning has become increasingly popular in both face-to-face and distance education settings. Computer technologies, as demonstrated in research and practice, can support collaborative learning and benefit learning in different ways (e.g., Harisim, 1990; Bonk & Cunningham, 1998; Scardamalia & Bereiter, 1994). Currently two approaches are dominant in the practice of peer online collaborative learning: peer controlled and externally moderated. In a peer controlled online collaboration the instructor does not play an active role in the collaboration process, providing little or no structuring or moderating efforts. In externally moderated and structured peer collaboration processes the instructor, or another qualified person from outside of the group, provides structuring and moderating efforts as needed.

A previous study (Zhang & Peck, 2003) found that externally structured and moderated online collaborative groups achieved significantly higher scores in reasoning during problem solving tasks when compared to the peer-controlled collaborative groups.

The study (Zhang & Peck) also showed that the two different approaches to collaboration led to differences in related individual attitudes. However, very little has been done to further examine the relative effects of these two different approaches on group problem solving processes during varied problem solving tasks. In her more recent research, Zhang (2003) found that these two approaches led to significant differences in group achievements on both well-structured problem solving and ill-structured problem solving, favoring externally structured and moderated collaboration. This study intends to take one step further and re-examine the relative effects of the two approaches and also to investigate the possible effects on individual learners' related attitudes.

Thus this study investigates the following major research questions:

- Question 1. Which approach to peer online collaboration is more effective, peer-controlled or externally moderated, in promoting college students' group problem solving process during well-structured problem solving?
- Question 2. Which approach to peer online collaboration is more effective, peer-controlled or externally moderated, in promoting college students' group problem solving process during ill-structured problem solving?
- Question 3. Do the two approaches lead to differences in individual students' attitudes related to online collaboration?
- 3.a Does the approach to collaboration lead to differences in students' perception of the difficulty of online collaboration?
- 3.b Does the approach to collaboration lead to differences in students' perception of the value of online collaboration?

3.c Does the approach to collaboration lead to differences in students' willingness to use a similar tool in the future?

3.d Do the two approaches to collaboration lead to different amounts of time spent in collaboration or the use of different media for collaboration (e.g. email, telephone, face-to-face, etc.)?

Question 4. Do students' prior experiences (i.e., statistics background, teamwork experiences, and online learning experiences) lead to differences in the problem solving processes?

Design:

A randomized post-test only experiment was used to investigate Questions 1 and Question 2. Seventy two groups, in size of 3-5, were randomly assigned to one of the two treatments. ANOVA was conducted to test the null hypotheses and thus to answer the first two research questions. Individual surveys were conducted to collect data to answer Question 3 and Question 4.

Results:

- ◆ Groups assigned to the externally structured and moderated online collaboration displayed significantly higher scores in well-structured problem solving process than those in the peer-controlled condition.
- ◆ Groups assigned to the externally structured and moderated online collaboration displayed significantly higher scores in a) the use of statistical knowledge, b) the use of strategic knowledge, c) communication and d) overall problem solving process during ill-structured problem solving than those in the peer-controlled condition.

- ◆ The two approaches did not lead to different amount of time spent on the collaborative task or the use of any of the communication media reported. Past experiences did not make a difference in group problem solving processes during either well-structured problem solving or ill-structured problem solving as measured in this study.

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## **Chapter 1**

### **PURPOSE OF THE STUDY**

#### **Introduction**

Collaborative learning has been gaining increased attention in the practice and research of education. Consistent with Vygotsky's (1978) social-cultural learning theory, research showed that working in small groups can facilitate learning as opposed to individual learning (i.e., Johnson & Johnson, 1975; Hamm & Adams, 1992; Bosworth & Hamilton, 1994; Bruffee, 1999). A lot of research has examined the effects of collaborative learning on individual learning outcomes; however, researchers argued that valid assessment of collaborative learning, practically (Dillenbourg, 1999) and theoretically (Perkins, 1993), should be looking at *group*, rather than individual achievement.

#### **Statement of the problem**

Research showed that learning in small groups improves achievement of various learning objectives (i.e., Johnson & Johnson, 1975; Hamm & Adams, 1992; Bosworth & Hamilton, 1994; Bruffee, 1999). With computer and networking technologies widely applied in both distance learning and traditional education settings, Dede (1996) suggested that online learning should become an integral part of higher education in the twenty-first century.

Two major different approaches to online peer collaboration have been widely used in education. One is peer-controlled, where instructor has little or no involvement in the process, and students take complete control over the collaborative process. Another is externally structured and moderated, where the instructor and/or other non-member experts offer structuring and moderating efforts during online collaboration. In general, researchers believe that learner control increases intrinsic motivation, and research showed that when participants have active control over the learning process, learning increases (Jensen, 1996). As related to collaborative learning, advocates for completely peer-controlled collaboration claimed that students usually feel more comfortable discussing without the presence of an instructor (Jensen, 1996). Yet at the same time, research found inconsistent results on the effects of learner control on learning outcomes (see Schnackenberg & Sullivan, 2000 for detailed discussion). Steinberg (1977) called for cautiousness given the negative impacts of learner control. Consistently, research indicated that a role of facilitator would smooth the process of collaboration (Johnson, Johnson, & Stanne, 1986; Hooper, 1992; Ruberg, Moore & Taylor, 1996).

As educators and researchers stress the importance of problem solving (e.g., Bransford, Brown, & Cocking, 2000; Bransford, Sherwood, & Sturdevant, 1987; Bransford & Stein, 1993; Jonassen, 1997; Schmidt, 1989), research indicated that students were not able to transfer knowledge and skills to solve problems cross contexts, even if they were able to do so in a familiar school setting (e.g., Bransford et al., 1987; Gick and Holyoak, 1980). In addition, Bruning (1994) commented that many college students were not able to direct their own learning effectively or productively. Thus external moderation may be helpful to create effective collaboration and problem solving.

Brandford, Brown, and Cocking (2000) suggested that the instructor should help students monitor the learning process when they were engaged in problem solving, especially ill-structured problems. In other words, the instructor should take an active role as an external moderator in the peer collaborative problem solving process.

A recent experimental study (Zhang & Peck, 2003) with groups in an undergraduate statistics course has found that externally structured and moderated online collaborative groups achieved significantly higher on reasoning in well-structured problem solving than the peer-controlled collaborative groups. The research also shows that the two varied approaches to online collaboration led to differences in individual students' attitudes toward teamwork and collaborative technology (Zhang & Peck). A qualitative analysis of students online collaboration (Zhang & Carr-Chellman, 2001) has also suggested that the externally structured and moderated groups were able to apply more strategies in the problem-solving process as well as in the group development process, and were able to use the strategies in a more effective way, as compared to the peer-controlled groups. Another study (Zhang, 2003) found that the externally-structured and moderated collaborative groups achieved significantly higher in both well-structured and ill-structured problem solving tasks as compared to the peer-controlled collaborative groups. Zhang proposes to further investigate why and how the varied approaches impact the group collaboration and thus make differences in group problem solving. Researchers (Zhang, 2000; Zhang & Carr-Chellman; Zhang; Zhang & Peck) suggested further studies are needed to investigate the relative effects of the two approaches on varied learning tasks, such as ill-structured vs. well-structured problems.



## Research Questions

This study intends to investigate the relative effects of the two different approaches to peer collaboration on college students' group problem solving processes during well-structured and ill-structured problem solving.

The following research questions will be investigated in this study.

Question 1. Which approach to peer online collaboration is more effective, peer-controlled or externally moderated, in promoting college students' group problem solving process during well-structured problem solving?

Question 2. Which approach to peer online collaboration is more effective, peer-controlled or externally moderated, in promoting college students' group problem solving process during ill-structured problem solving?

Question 3. Do the two approaches lead to differences in individual students' attitudes related to online collaboration?

3.a Does the approach to collaboration lead to differences in students' perception of the difficulty of online collaboration?

3.b Does the approach to collaboration lead to differences in students' perception of the value of online collaboration?

3.c Does the approach to collaboration lead to differences in students' willingness to use a similar tool in the future?

3.d Do the two approaches to collaboration lead to different amounts of time spent in collaboration or the use of different media for collaboration (e.g. email, telephone, face-to-face, etc.)?

Question 4. Do students' prior experiences (i.e., statistics background, teamwork experiences, and online learning experiences) lead to differences in the problem solving processes?

### Null Hypotheses

Based on the above research questions, the following null hypotheses have been developed:

Hypothesis1: There will be no significant difference in the means for group problem solving process during well-structured problem solving between peer-controlled online collaboration groups and externally-moderated online collaboration groups.

Hypothesis2: There will be no significant difference in the means for group problem solving process during ill-structured problem solving between peer-controlled online collaboration groups and externally-moderated online collaboration groups.

Hypothesis3a: There will be no significant difference in students' perceived difficulty of online collaboration between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.

Hypothesis3b: There will be no significant difference in students' perceived value of online collaboration between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.

Hypothesis3c: There will be no significant difference in students' willingness to use a similar tool in future between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.

Hypothesis3d: There will be no significant differences in the means for the time spent on collaboration or the use of different media for collaboration between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.

4.a Students' past experiences (e.g., Mathematics/Statistics background, team work experiences, and online learning experiences) lead to no differences in well-structured problem solving process.

4.b Students' past experiences (e.g., Mathematics/Statistics background, team work experiences, and online learning experiences) lead to no differences in ill-structured problem solving process.

### **Project Significance**

Online collaboration has been increasing popular in both distance education and traditional learning institutions. Problem solving has been identified as one of the challenging learning objectives for college students (e.g., Bransford et al., 1987; Gick & Holyoak, 1980). Researchers have been investigating online collaborative learning and problem solving from different perspectives, yet little formal empirical research has investigated which approach to online collaboration is more effective in promoting group achievement during problem solving. It is the objective of this study to collect data that

will establish the empirical justification for the use of online peer collaboration and will identify the relative merits of the different approaches to online collaborative learning. In addition to responding to a current need in education today and extending research and practice initiated by other researchers, this investigation anticipates the following intended outcomes:

- Determination of the relative effects of the two approaches to online peer collaboration on group problem solving processes during two types of problem solving (well-structured and ill-structured);
- Practical implications for instructors as to their role in the learner-centered, online collaborative learning environment;
- Practical implications for instructional designers when designing an online collaborative learning environment;
- Practical implications for collaborative groups in an online collaborative learning environment.

### **Generalizability of the Research**

This study was implemented in a typical, large undergraduate class in a large public university on the eastern coast of the United States. The class from which the participants were recruited was required by most academic majors in the eleven colleges and schools in that university. Participants recruited were highly heterogeneous in terms of ethnicity, gender, age, and academic backgrounds. Since the subjects were from a normal class, it may be concluded that the general findings are appropriate to similar

types of students in a similar higher education institution. In addition, the subjects recruited in this study were a very heterogeneous group, and the results of this study may be concluded to other similar, heterogeneous populations. However, the content dealt with statistics at the college level, so caution should be exercised when applying these results to other areas.

### **Definition of Terms**

In an attempt to alleviate any confusion due to the use of different terminology, relevant terms are defined based on how they are used in this study.

#### **Collaboration:**

A process of mutual engagement of participants in a coordinated effort to reach a shared goal. Bruner (1991) specifies that the collaboration process includes jointly developing and agreeing to a set of common goals and directions; sharing responsibility for obtaining those goals; and working together to achieve those goals, using the expertise of each collaborator.

#### **Problem solving:**

A higher-ordered learning outcome, which involves dealing with new and unfamiliar tasks, obstacles, and an unknown relevant solution (Gredler, 1997). In Gagne's conditions of learning, problem solving is the skill of recalling and applying a set of rules in the proper sequence to solve a problem.

#### **Well-structured problems:**

Problems that have a pre-defined initial state and goal settings and a set of logical operators (Jonassen, 1997; Greeno, 1978).

Ill-structured problems:

Problems that are situated in a specific context, but without well-defined goals, and the information needed to solve the problem is not provided in the problem statement (Chi & Glaser, 1985; Jonassen, 1997).

## Chapter 2

### LITERATURE REVIEW

#### Introduction

Collaborative learning has been gaining increased attention in the practice and research of education. Computer technology is now widely applied to support collaborative learning in traditional and distance education settings (Bonk & Cunningham, 1998), and has further extended the time, space and formats for collaborative learning. Dede (1996) suggests that online learning should be integrated into higher education in the twenty first century. A lot of research has been conducted to examine the effects of collaborative learning on individual achievements, yet very little has been done to investigate the possible impacts on *group* achievement. Researchers propose that, both practically (Dillenbourg, 1999) and theoretically (Perkins, 1993), valid assessment of collaborative learning should look at group achievement.

As related to the purpose of this study, a review of literature in the following five areas is presented in this chapter, sociocultural learning theory, collaborative learning, computer-supported collaborative learning (CSCL), problem solving, and structuring and moderating online collaborations.

## **Sociocultural Learning Theory**

Sociocultural learning theory is one of the learning theories that support collaborative learning. Vygotsky initiated the research on human psychological development from a social-cultural history method (Gredler, 1997). He proposed that learning is a developmental process occurring in social activities (Vygotsky, 1978; Driscoll, 1994), and that complex, higher-order thinking was gradually developed through social interactions with others in the culture (Vygotsky, 1978; Gredler, 1997). According to Sociocultural theorists, people learned from mediations and scaffoldings, which were offered within one's zone of proximal development (ZPD) from experts or capable peers (Wertsch, 1985; Gredler, 1997; Bonk & Cunningham, 1998). Vygotsky defined ZPD as the distance between a person's independent competency and that obtained with assistance from an expert or in collaboration with more capable peers (Wertsch, 1985). Such a distance can be bridged and extended through scaffolding efforts, as external assistance is gradually reduced and the learner finally achieves independent competency in the task (Gredler, 1997). Research showed that successful group learning promoted higher order thinking (e. g., Blumenfeld, Marx, Soloway, & Krajcik, 1996). Research and scholarship also claimed that computer supported collaborative learning environment can provide the Zone of Proximal Development (ZPD) (Salomon, Globerson & Guterman, 1989; Newman, Griffin & Cole, 1993). In collaborative learning environment, learners' ZPD can be reached and extended through communications and collaborations with peers and the instructor. Thus a role of a moderator, performed by the instructor or another capable expert, may help learners reach



and extend their ZPD for problem solving in the collaboration process. Research supports the premise that the role of moderator can smooth the process of collaboration (Hooper, 1992; Ruberg, Moore & Taylor, 1996).

### **Collaborative Learning**

Collaborative learning has been increasingly popular in research and practice of education. Compared to isolated individual learning, peer collaborations increased individual engagement in the learning process, and facilitated cognitive development (Cazden, 1988). Consistent with sociocultural theory, research showed that peer group work had positive impacts on varied learning outcomes (e.g., Jonassen, Davidson, Collins, & Campbell, & Haag, 1995; Berge & Collins 1995). Research showed that there were clear educational advantages to be derived from collaborative activities among students (Del Marie Rysavy & Sales, 1991; Slavin, 1992).

Cazden (1988) suggested that learners could learn in a constructive way and benefit in cognitive development when they were guided to reflect upon and confront different ideas through peer collaborations, and asked to provide support and meaningful feedback to one another. Researchers argued that to learn and work with a small group could facilitate learning as opposed to individual learning (Johnson & Johnson, 1975; Hamm & Adams, 1992; Bosworth & Hamilton, 1994; Bruffee, 1999).

Collaborative learning environments provide a means to create more engaging and dynamic instructional settings. Research (Johnson & Johnson, 1975; 1992; Clements & Nastasi, 1988) showed that in peer collaborative learning environments, learners

shared knowledge and thinking, and the interpersonal communications enabled and encouraged learners to confer, reflect up and develop meaningful learning. In a meta analysis of the research on small-group learning in science, mathematics, engineering, and technology (SMET) at the undergraduate level after 1980, Springer, Stanne, and Donovan (1999) found that small groups demonstrated greater academic achievement, expressed more favorable attitudes toward learning, and persisted through SMET courses or programs to a greater extent compared to the more traditionally taught ones.

With all the potential benefits; however, collaborative learning brings new challenges to instructors on how to define their role in the learning process, as it changes the traditional teaching and learning practice. The instructor is no longer a “knowledge giver” or the center of authority in collaborative learning environments. Yet more empirical studies are needed to investigate the changed role of instructor and the effects of collaborative learning on various learning outcomes.

### **Computer Supported Collaborative Learning**

The emergent technologies have been extending collaborative learning in many ways. Varied forms of computer supported collaborative learning (CSCL) have been adopted in education of both cognitive and affective domains (Clements & Nastasi, 1988; Hoopers, 1992; Repman, 1993; Jehng, 1997; Rada & Wang, 1998). The Internet has made it possible for learners to collaborate beyond the classroom, to expand learners’ control over the time for collaboration, and increases the time available to read, to reflect upon and to reply to a message and concrete ideas in writing. Online collaboration

forums, for example, further facilitate self-paced and self-controlled learning and collaboration. In addition, scholars (Vygotsky, 1978; Harasim, 1990) believe that the change from oral to verbal communication contributes to learning effectiveness when learners have to articulate and elaborate their thinking in writing. Asynchronous online forums also extend the time span for peer collaboration, and therefore can possibly improve in-depth investigation of the collaborative task (Harasim, 1990).

Virtual discourse in online forums makes participants' thinking and reasoning visible (Lin, Hmelo, Kinzer, & Secules, 1999), and facilitates delayed reflection (Scardamalia & Bereiter, 1994; Blumenfeld, Marx, Soloway, & Krajcik, 1996). It is also reported that some students that were not comfortable in classroom collaboration could be very active and engaged online, since there was no time restriction or competition or interruption from more aggressive peers (Harasim, 1990). In an asynchronous online collaborative environment, the less aggressive learners can have the same time and opportunity to express themselves, without having to worry about being interrupted by more aggressive peers. In this sense, it may help ensure equal opportunity in peer collaboration. It may also, as a result, help establish positive group dynamics, which is very important for online collaborative learning.

With all the benefits and potential, online collaboration does bring new challenges to learners. The lack of non-verbal communication in an online forum makes misunderstanding and miscommunications less detectable, and thus requires higher communication competency in writing. Concerns for miscommunications can make participants more conscious and nervous about writing and diction in their online collaboration efforts. Technology anxiety or frustration is often reported as well (e.g.,

Zhang & Harkness, 2002). Zhang and Ge (2003) argued that different team tasks, in terms of the complexity, structure and type, have different requirements for media richness and social presence. Thus media selection should be aligned with the needs of the particular task. Problem solving tasks, especially ill-structured ones, may require more accurate information communication and transmission, and there may be strong needs for perceived presence of peers, especially when questions have been asked or disagreements have occurred. However, online forums are not considered rich media and do not convey social presence very well, according to media richness theory (Daft & Lengel, 1984) and social presence theory (Short, Williams & Christie, 1976) respectively. Susman, Gray, Perry and Blair (2003) also pointed out that virtual teams were faced with psychological and social challenges as they adopted collaborative technology and leveraged it later in a broader organizational context. The technology itself has constraints and brings challenges when rich information is needed and/or there are strong needs for social presence. A role of moderator, performed by the instructor or another expert, may be able to facilitate the online collaboration process by help reducing the anxiety associated with technology and communication media. The external moderating efforts may address some of the psychological needs that online learners have by presenting the connections from the instructor or another expert who performs the role of a moderator.

Harasim (1990) reported that consensus was generally more difficult to achieve in online collaborations and the quality of decision might be sacrificed to compromise the delays in the process. Research also showed that online collaborative learning appeared to be a double-edged innovation to college students in a traditional university in the

United States, and challenged learners with not only the new technologies it utilizes but also the notion of collaboration as opposed to the strong individualistic culture in the United States (Zhang, 2002). As a relatively new learning method, online collaboration itself is a learning process that needs scaffolding from capable experts to smooth the process as well as guiding the content learning.

All the challenges from the constraints of the communication media and the change of learning methods generate the needs for moderation in the collaborative learning process. Accordingly, the role of instructor changes from the center of authority to a moderator in the collaborative learning environments (Hamm & Adams, 1992; Flannery, 1994; Bernard, Rojo de Rubalcava, & St-Pierre, 2000). Instructors are expected to provide supports in the collaborative learning process such as motivating students, monitoring and regulating performance, provoking reflection, modeling, moderation and scaffolding (Brown & Palinscar, 1989; Hamm & Adams, 1992; Bosworth & Hamilton, 1994; Brandon & Hollingshead, 1999; Jonassen, 1999). Hannafin, Land and Oliver (1999) classified the scaffolding efforts as conceptual, meta-cognitive, procedural and strategic. Basically, conceptual scaffolds are the efforts to guide students on what to consider; meta-cognitive scaffolds guide learners on “how to think”; procedural scaffolds focus on how to utilize the available features (i.e. tools and resources) in the learning environment; strategic scaffolds assist students in analyzing and approaching learning tasks or problem, and they can be provided initially as macro-strategy or ongoing as needed (Hannafin et al, p. 131). The literature provides insight into the possible needs for moderation in collaborative learning.

## **Problem solving**

Problem solving is increasingly emphasized as an important goal for learning (e.g., Bransford, Brown, & Cocking, 2000; Bransford, Sherwood, & Sturdevant, 1987; Bransford & Stein, 1993; Jonassen, 1997; Schmidt, 1989). Researchers point out that instructors play a critical role in the problem-based learning process, as a moderator to foster active and effective learning (e.g., Barrows & Tamblyn, 1980; Barrows, 1985, 1996; Coles, 1991). Ill-structured problems and well-structured problems differ in certain ways, and those differences may lead to varied needs for external moderation. The following review of literature focuses on the different characteristics of well-structured problems and ill-structured problems, to build an understanding for the possible different needs for moderation in the collaborative problem solving process.

### **Ill-structured Problem vs. Well-Structured Problem**

Ill-structured problems are typically complex and loosely defined. In general, ill-structured problems have the following characteristics: a ) the goals are not clearly stated nor exclusively specified (Voss & Post, 1988); b) all the needed information to reach the final solution is not clearly identified or described in the problem statement (Chi & Glaser, 1985); c) the path(s) to the final solution(s) or to solve the problem is not clear, and/or may not be exclusive, and d) the solution to the problems could involve more than one or none at all (Kitchner, 1983). On the contrary, well-structured problems typically have a well-defined goal, an optimal solution path, and a single/optimal solution, and the

information needed is either limited or sufficiently stated (Greeno, 1978; Sinnott, 1989; Jonassen, 1997).

The differences between well-structured and ill-structured problems as stated above thus lead to different needs for moderation in the problem solving process. Problem-solving processes is generally a process to search through cognitive possibilities. General Problem Solving (GPS) (Newell & Simon, 1972) and the IDEAL problem solver (Bransford & Stein, 1993) are two of the well-accepted problem solving models, both of which describe the problem solving process and identify the critical steps for successful problem solving. Despite all the differences between these two models, in general, both agree that problem solving involves the processes of understanding the problem itself and searching for the solution(s) accordingly. For well-structured problems, the understanding of the problem itself might be easier as compared to the process of searching for solutions. Yet for ill-structured problems, clearly defining the problem is the very first and critical step for successful problem solving. Thus as students may spend more time at the solution-search stage for well-structured problems, there probably is a great need for more effort at the problem definition stage in an ill-structured problem. Thus the possible needs for moderation may well differ for the two types of problems at different stages of problem solving. The research on working groups with collaborative technologies suggests that the characteristics of a group task lead to variation in group interaction (Zigurs & Buckland, 1998). Unfortunately there is not much research investigating the possible different effects of moderation on the varied types of problem solving tasks. Zhang's recent research (2003) investigated the relative benefits of the two approaches to online collaborative learning on group achievement of

the two types of problem solving tasks, and it showed that moderated groups performed better in both types of problem solving tasks. The researcher hopes that this study will add additional light on the previous findings and help build a better understanding of how moderations can make a difference.

### **Structuring and Moderating Online Collaboration**

In general, it is believed that learner control increase intrinsic motivation, and research showed that when participants had more active control over the learning process, learning increased (Jensen, 1996). Yet Steinberg (1977) argued that learner control could increase anxiety and frustration, while maintaining attention and increasing motivation. Research yielded inconsistent results regarding the benefits of learner control on learner achievement (see Schnackenberg & Sullivan, 2000 for a detailed discussion).

As Aviv and Golan (1998) reported, in distance learning environments most students participate in electronic discussions passively, and very few students actively raise questions. Aviv and Golan (1998) also found that when collaboration was preplanned, and focused, and when students were led through the learning process, the electronic discussions led to a highly successful learning experience. Slavin (1995) recommended the use of a structured protocol to direct interactive discourse among peer learners to reduce off-track and passive behaviors while ensuring opportunities for equal participation.

As the focus changes from “teaching” to active “learning”, the instructor needs to take substantial responsibility to foster a learner-centered peer collaborative learning



environment. As for students' participation in online collaborations, strong social skills and good group dynamics are essential to effective and productive learning outcomes. Group dynamics contribute to students' performance in collaborative learning and their satisfaction for the learning experience (Bosworth & Hamilton, 1994). Some participants' actions of "free riding" and "social loafing" and failure to contribute, however; can damage others' enthusiasm and motivation in the course of collaborative learning. In addition, the feeling of "talking in a vacuum" with online collaboration and other frustrations with technology and many other factors make online collaboration a challenge to many participants. Research indicates that even in learner-centered learning environment, as in online collaborative learning, moderations and structuring of the learning process are needed for successful learning experiences (Flannery, 1994). Online collaborations need to be well-organized, facilitated, and moderated to be effective and successful (Hamm & Adams, 1992; Flannery, 1994).

Little research has been focused on how to structure peer online collaboration. In practice, peer collaborations are often structured by learners themselves while they chunk the group assignment into "detailed division of labor" (Althausen & Matuga, 1999). In order to reduce "free riding" in teamwork, instructors also often structure the online peer collaborations by assigning a set of questions to each member of a group. Therefore every group member must participate by taking charge of the part of the task to which they are assigned. Such structuring, however; has drawbacks, as it tends to lead students to work on the group assignment in a co-operative way and thus they may miss the opportunity for collaborative learning. Individuals can execute their own part of the

assignment without collaborative efforts from peers, and they may not contribute to other parts of the assignment either.

Bosworth and Hamilton (1994) suggest that instructors create and develop requisite structure and process of the group to achieve better collaborative learning. Similarly, Slavin (1995) suggests using structured protocols to direct student interactions.

The importance of moderating peer collaborative learning has been recognized in practice and research (Harasim, 1990; Hamm & Adams, 1992; Bosworth & Hamilton, 1994). Bernard et al (2000) also suggest that instructors assume a facilitator's role in an online collaborative learning environment. Strategies for online forum moderation include, but are not limited to the following: to maintain the discourse focused on the topic, to check team progress, to promote equal participation, to provide individual support as needed.

Recently Zhang and Peck (2003) found that structuring and moderating efforts on group work and the collaboration process in online forums led to stronger reasoning in a group problem-solving task in self-selected groups in a traditional college. A more recent study (Zhang, 2003) also showed that groups that had received external structuring and moderation performed significantly better in both well-structured and ill-structured problem solving tasks. The researchers (e.g., Zhang, 2003; Zhang & Peck, 2003) called for more empirical studies to further examine the effects of external moderation on different types of collaborative tasks.

## Summary

Sociocultural learning theory supports the role of a moderator in the collaborative learning process, performed by the instructor or another expert, to help bridge and extend the ZPD through peer collaborative learning. Research showed that learning in small groups was effective in improving academic achievements in science, mathematics, engineering and technology in undergraduate education (see Springer, Stanne, & Donovan, 1999 for a meta analysis), and some indicated that a facilitator would smooth the collaboration process (Johnson et al, 1987; Hooper, 1992; Ruberg, Moore & Taylor, 1996). Online forums with Internet technologies could facilitate collaborative learning and delayed reflection (Lin et al, 1999). Yet learners are faced with a lot of challenges during online collaboration, due to the characteristics of the communication technology as well as the less traditional, collaborative learning method. Various forms of scaffolding can be provided during the course of online collaboration, and moderations are well needed to achieve smooth, effective online collaborative learning. It is strongly recommended by research that structuring, moderating and scaffolding efforts should be provided in peer online collaboration for learning purposes. This study will empirically test the effects of two approaches to peer online collaboration, the peer-controlled and the externally structured and moderated, on group problem solving. It will also investigate the individuals' related attitudes toward online collaborative learning.

## Chapter 3

### RESEARCH METHOD

#### Context of the Study

The study was implemented in a large undergraduate course in statistics in a large land-grant university in northeastern United States. The class, from which all the participants were recruited, was well-known for its successful, innovative practice with group learning activities, and the instructor was very experienced with creating, guiding and moderating group activities in person, as well as online. It was the first semester that this course implemented Cyberstats (<http://www.cyberk.com>), a comprehensive web-based courseware as the major teaching and learning venue, together with computer lab sessions. The courseware included a course management system for instructors and asynchronous discussion forums for groups and entire class. It was the first time that Cyberstats had integrated the group communication features, and it was the first time the instructor and the students used this courseware in its full capacity. In addition to the Cyberstats courseware, the students also had a printed textbook that supplemented the electronic course modules, and there were lab sessions where they could meet in person. Thus it was a typical hybrid course with both traditional face-to-face lab sessions and web-based courseware and electronic collaboration tools.

## Participants

All participants were recruited from three sections of the same course with the same instructor. The potential participant pool consisted of approximately 80 groups in size of 3 to 5, totaling of approximately 300 students. At the beginning of the semester, all students enrolled in this statistics course were asked to form groups of four. Students enrolled at this course came from different colleges/schools in different academic programs and from different classes (freshman to senior). Most of them did not know each other before coming to this course. They formed self-selected groups mostly based on where they happened to sit in the computer lab. Students who decided to be in the same group wrote down their names on a same card. The teaching assistant then collected all the cards with the members' names, and wrote a number on the card for each group, and this became their group number. The group number was composed of three digits, the first being the section number, and the next two being a number from 1 to 20 depending on where the group sat in the lab. The teaching assistant then randomly assigned the groups to the treatments of this study, the peer-controlled condition or the externally-moderated condition. Block randomization was performed to ensure there was approximately the same number of groups from each of the three sections and approximately same number of groups from the same seating location in the lab. The teaching assistant flipped a coin to decide which treatment each group goes to. To encourage active collaboration through the online courseware, students were told that they would receive up to 25 extra credits for quality participation in the particular group assignment used for this study. The extra credits were granted based on peer review and

the teaching assistant's evaluation of their online discussion, and they were not collected by the researcher or reflected in any of the problem solving achievement scores in this study.

### **Research Design**

To investigate the research questions as stated in Table 3.1, the researcher decided to conduct an experimental study together with pre- and post- surveys. The research questions, research design, data collection methods and data analysis methods are presented in Table **3.1**.

Table 3.1: Overall study questions, data collection techniques, instruments and data sources

Research Question	Data Collection	Tasks/Materials/Instruments	Data Sources	Data Analysis
1. Which approach to peer online collaboration is more effective, peer-controlled or externally moderated, on college students' group problem solving process during well-structured problem solving?	Experimental study	Well-structured problem solving task; Scoring rubric for well-structured problem solving task	Well-structured problem solving score	ANOVA
2. Which approach to peer online collaboration is more effective, peer-controlled or externally moderated, on college students' group problem solving process during ill-structured problem solving?	Experimental study	Ill-structured problem solving task; Scoring rubric for ill-structured problem solving task	Ill-structured problem solving score	ANOVA, MANOVA
3 a. Does the approach to collaboration lead to differences in students' perceived difficulty of online collaboration?	Experimental study survey	Self reported post-survey	Post survey	ANOVA
3 b. Does the approach to collaboration lead to differences in students' perceived value of online collaboration?	Experimental study survey	Self reported post-survey	Post survey	ANOVA
3 c. Does the approach to collaboration lead to differences in students' willingness to use a similar tool in the future?	Experimental study survey	Self reported post-survey	Post survey	Mean, ANOVA, reliability test
3 d. Do the two approaches to collaboration lead to different amounts of time spent in collaboration or the use of different media for collaboration (e.g. email, telephone, face-to-face, etc.)?	Experimental study survey	Self reported post-survey	Post survey	Mean, Mann-Whitney 2-sample test for equality of medians
4. Do students' past experiences (such as Mathematics/Statistics background, team work experiences, and online learning experiences) lead to differences in problem solving processes?	Survey	Self reported pre-survey; Well-structured problem solving task; Scoring rubric for well-structured problem solving task; Ill-structured problem solving task; Scoring rubric for ill-structured problem solving task	Pre survey; Well-structured problem solving score; Ill-structured problem solving score	Mean, scatter plot, linear regression

## **The Experimental Design**

The experimental study was a randomized post-test only control group design. Stratified randomization was performed by the seating location in the lab for each section of this course. All self-selected groups, stratified by front row, middle row and back row, were randomly assigned to either of the two conditions: peer-controlled or externally-structured-and-moderated online collaboration. All groups were given a team project, which consisted of a well-structured problem and an ill-structured problem. They had two weeks to complete these problems; and all members in the same group received the same grade for this group assignment.

### **Treatments**

In this course students had a hard copy of instructional materials that accommodate Cyberstats courseware. Syllabus, announcements, assignments, quizzes and readiness tests were all available electronically through Cyberstats as well. Problem solving tasks were assigned to each group, and all groups had two weeks to complete the assignment and submit it as a group assignment. Members in the same group received the same score for each of the problem solving tasks.

Treatment 1: peer-controlled online collaboration (PC)

Treatment 1 served as a control in this study.



All groups that were randomly assigned into this treatment were provided with a private online forum, where only members of the group were able to post and reply to messages. For these private forums, no moderation or any other interventions were performed by the instructor or anyone else from outside of the group, and students were in complete control over the collaboration process.

Treatment 2: Externally structured and moderated online collaboration (ESM)

All groups that were randomly assigned into this treatment were provided with a private online forum, where the instructor, in consultation with the researcher, provided moderations as needed throughout the collaboration process. In addition to the group discussion forum, the moderators could and did choose to use other communication methods as appropriate (e.g., personal email), and may use more than one medium at the same time if needed. The moderations included, but were not be limited to, the following:

A. Structuring the group process:

- Request the groups to work out a team contract before they get into the problem solving tasks
- Help the groups to construct a team contract, as needed

B. Moderating the collaboration process:

- Keep the discussion on the topic
- Check the problem solving progress, remind users of the timetable
- Encourage and support individuals for equal participation
- Help overcome technology anxiety or frustration, as needed
- Help maintain positive team dynamic

- Motivate the groups and individuals, as needed
- Promote appropriate use of the learning tools (e.g., purpose of the online collaborative forums, language for online communication, etc.)

## **Materials**

The instructional content covered in the assignments in this study were instructional units about descriptive data, survey design and development, types of experiments and regression in elementary statistics at the college level. Most of the contents covered in the group assignments were not lectured by the course professor but were accomplished through self learning and peer tutoring. Learners had limited opportunities to work on these problems in the face-to-face computer lab sessions during the two weeks. Both problem solving tasks were assigned as group projects. The well-structured problem (Appendix A) consisted of a set of sub-problems, which also served as a guide to understand the problem from statistics perspective and to reach a solution. The ill-structured problem (Appendix B), on the contrary, was loosely-defined and thus required the groups to figure out the sub-problems and final solutions on their own.

### ***Validating the problem-solving tasks***

A validation tool (Appendix C) was developed to assess the validity of these problems. The validation tool served two purposes: 1) to make sure these assignments were really problem solving tasks and not other types of tasks; 2) to validate these

problems were really the type of problem as they were intended to be. A mathematics education professor reviewed the problem solving assignments and filled out the validation form with comments and suggestions. The researcher also talked with the expert reviewer to try to reach a closer understanding of the review comments. Then the researcher and the course instructor went through these comments together, and made revisions as needed to ensure these were problem solving tasks and that they were distinguished from each other as different type of problem solving tasks (i.e., ill-structured vs. well-structured).

### **Criteria Measures**

As well-structured problems and ill-structured problems were very different from each other by nature, a different assessment tool was developed for each of the two types of problem solving.

#### ***Assessment Tool for well-structured problem solving process***

The well-structured problem solving process was assessed with specified criteria with correct answers and score allocations specified for each sub-question (Appendix D). Scores for well-structured problem solving process could theoretically range from 0 to 40, and will be referred to as WP in this report.

***Reliability of the well-structured problem solving process assessment Tool***

Two graders, who had no knowledge about or contact with any of the participants, reviewed all the well-structured problem solving assignments and graded them independently. 8 out of 72 group submissions received a different score from the two graders, with 5 of them differed by 2 and 3 differed by 3. The correlation of the two rater's scoring for the well-structured problem solving process was significant at the .01 level (Pearson correlation was .972).

After the individual grading, the two raters worked together on the disputed scores. They negotiated and reached agreement on those scores. The jointly-agreed scores were analyzed in this study.

***The assessment tool for ill-structured problem solving process***

Lane (1992) suggested a theoretical framework for constructing assessment tools for mathematics problem solving, with mathematical knowledge, strategic knowledge, and communication as the three areas for mathematics problem solving, with ratings from 0 to 4 for each area (p.12). This framework, which includes the quality of the solution but focuses primarily on process, was well-received and applied for not only math problem solving evaluation but also general assessment of extended-response problems (e.g., Illinois State Board of Education, 2003). Since statistics problem solving is very similar to mathematics problem solving, Lane's framework was considered a valid and credible foundation to develop the scoring rubric for the ill-structured problem in this study.

After the ill-structured problem had been validated and finalized, the course instructor worked out a checklist with the major factors that should be included in the solution. These factors matched the characteristics that Lane specified in the framework, and they were well covered in the three areas as well. So the ill-structured problem solving was assessed based on the three areas, the use of statistical knowledge (referred to as SK), the use of strategic knowledge (ST) and communication (CM). SK, ST and CM scores range from 0 to 4, with 0 being the poorest and 4 being the best. A total score (OIP) was generated to represent the overall problem solving process during ill-structured problem solving. The three areas were weighted differently. Because the use of content knowledge and strategic knowledge were both critical to reach a plausible solution, each of them was weighted as forty percent (40%), and communication was weighted as twenty percent (20%), of the total score of ill-structured problem solving. The OIP could range from 0 to 100, theoretically.

When all groups had submitted the ill-structured problem solving assignment electronically, ten submissions were randomly picked from the pool. Each of the graders received a hardcopy of the same ten group submissions. They independently reviewed these assignments and used the above-mentioned scoring rubric to assess them. Some groups received the same score from both raters in the same area. The graders, together with the researcher, then through collaborative efforts identified and specified the shared characteristics of those receiving a same score. They then added examples from the real group submissions into the rubric as a quick reference for grading. This collaborative effort not only improved the scoring rubric, but also helped the raters to build a shared understanding of the assessment tool. The improved rubric was then applied to the

independent, blind review of all the group submissions of ill-structured problem solving by the two graders.

### ***Reliability of the assessment tool for ill-structured problem solving process***

The correlations of the scores by the two raters were significant at the .01 level in the use of statistical knowledge (Pearson Correlation was .852), the use of strategic knowledge (Pearson Correlation was .886) and communication (Pearson Correlation was .857). The overall ill-structured problem solving process (OIP) was also significant at the .01 level (Pearson Correlation was .899).

### **The surveys**

To investigate research questions 3 and 4, pre-survey and post-survey were developed. Both the pre and post surveys were administered to individual participants. The pre-survey was concerned with the participant's prior experiences as related to statistics, online learning and teamwork. A few items were adapted from Schau's (2003) survey of attitudes toward statistics to gather data as needed to answer the research questions in this study. The pre-survey was constructed into three areas, statistics background, teamwork experience and online learning experience. The post-survey was adapted from a previous study (Zhang & Peck, 2003) with questions regarding time, media and related attitudes, together with questions regarding teamwork and online

learning similar to those in the pre-survey but specifically referred to the experiences in this online collaborative problem solving process.

### **The Implementation Procedure**

All prospective participants received a general explanation of the study during the recruiting process. In a scheduled lab session all prospective participants received a hard copy of the detailed written explanation of the study and were asked to sign an informed consent form, if they decided to participate.

As part of the normal practice of this course, students were asked to form self-selected groups in size of four at the beginning of the semester. Block randomization was performed to ensure that each treatment had a same number of groups from the same section from the same seating location in the lab. However, at the time the study started, which was over a month after the team formation and randomization, changes had occurred in some groups with members dropping off the course, and some groups merged or split, and the group size changed as a result. Thus the two treatments did not have exactly the same number of groups of the same size, but the numbers remained close. A private forum was set up for each group by the teaching assistant. As part of the normal practice of this course, all students were using Cyberstats, the comprehensive courseware, from the beginning of the semester. Prior to the implementation of this study, many learners had already used the group collaboration forum available at Cyberstats for a group project. Students were strongly encouraged to collaborate through the online forum at Cyberstats for their second group project, from which the problem solving data would

be collected for this study. To promote and recognize active online collaboration, the students could receive up to 25 extra credits for quality participation. The extra credits would be granted based on the member review and the teaching assistant's review of their online discourse. The extra credits were not reflected in the group problem solving scores for this study.

Prior to assigning the problem solving tasks, a pre-survey (Appendix E) was conducted to collect data concerning students' prior experiences with statistics, team work, and online learning.

In the third week of the second month of the semester, all groups received the same well-structured and ill-structured problems as Part 1 and Part 2 respectively of the group project. They had two weeks to complete this assignment. During the two weeks, the instructor provided structuring and moderating efforts to the groups assigned to the ESM condition, as needed. The researcher was also monitoring the online collaboration closely, and was in frequent contact with the instructor to discuss the team dynamics, the needs for external moderation or structuring, and how to provide it (e.g., what medium to use, and when to intervene, etc.). The researcher developed an observation sheet (Appendix F), which was adapted and modified from a previous study (Zhang, 2003), to record her observations of the dynamics of the online collaboration. Information gathered in the observation sheet was shared with the instructor as a quick reference for the team dynamics in the discussions on the need for moderation.

When the assignments were due, the groups submitted their report electronically to the instructor, and the instructor forwarded them to the researcher by email. Some groups only submitted a print copy to the instructor, and some only submitted one of the



problems electronically. These hard-copy-only submissions were not forwarded to the researcher and thus were not graded or analyzed in any way in this study. Two raters were asked to blindly review the group submissions, independently, with the pre-determined assessment tools. They both had strong background in education and statistics, and they came in with expertise in both the content area and assessment from the instructional design perspective. Neither of the graders had participated in the online collaboration in any way, nor did they know any of the participants or the treatment condition they were assigned to. The researcher removed the cover sheet with the group members' names and ID numbers, and wrote down the group number on the first page of the group submission. The researcher also separated the well-structured problem solving submission and the ill-structured problem solving submission for each group, so that the raters did not have to grade the two different problems for each group at the same time and their assessment of one of the problems would not interfere with their assessment of the other. After independent grading, the raters worked together to discuss the disagreements of scores, and reached consensus on each of them. The agreed scores were analyzed for the purposes of this study.

When all groups had submitted the group problem solving assignment, a post-survey (Appendix G) was conducted to collect data regarding their online collaboration experience in this study.

## **Data Analysis procedures and methods**

Data collected in this study included group scores of well-structured problem solving and ill-structured problem solving, and individually self-reported pre-and post-surveys. The following describes the data analysis procedures and methods in detail.

### **Problem Solving Process Data Analysis Procedures**

The data collected in the experimental study was analyzed by the means of analysis of variance (ANOVA). ANOVA is a procedure for analysis of variance for models containing two or more dependent variables (Huck & Cormier, 1996). ANOVA was conducted to determine if there was statistically significant difference between the two variables. The alpha was set at .05 level of significance.

### **Self-reported Survey data Analysis Procedures**

Most participants completed both the pre- and post-surveys. The survey data was analyzed for the purposes of the study as specified in the research questions.

#### ***Pre-survey data analysis procedures***

Data collected in the pre-survey was used to generate a profile of the participants' background information, and then to help answer research question 4. The pre-survey was composed of three areas, statistics-related experiences (Questions 1-6), teamwork

experiences (Questions 7-10) and online learning experiences (Questions 11-19), with a Likert scale of 7 for all of the questions with 1 being strongly disagree and 7 being strongly agree, except for Question 7 with a “yes” or “no” response. Some items in this survey (e.g., Questions 10, 11, and 15) were written as negative statements and all the others were positive. So the responses to these negative statements were adjusted using the following math formula: (8- original response), so that the values were well aligned with the rest of the survey. The aligned responses were used in the survey data analysis.

For each area, the mean was calculated and ANOVA was employed to test if there was significant difference between the two treatments (null hypothesis:  $TR1=TR2$ ). In addition, a reliability test was run for every question area to determine the Cronbach Alpha reliability values.

To investigate Research Question 4, linear regression was employed to test if past experiences of the teams led to any differences in group problem solving process (e.g., WP, SK, ST, CM, and OIP respectively). As the survey data was individual values, yet the problem solving scores were group values, to investigate the effects of past experience on *group* problem solving process, the highest and lowest individual means in each experience area (statistics, teamwork and online learning) were analyzed for each group. In their review of the research and literature on work groups, Guzzo and Shea (1992) found that almost all group research reflected an underlying input-process-output model. The group research suggests that the qualities that each member brings to the team are inputs, such as expertise, personality and strength. The inputs are then processed in the group interactions and later transformed into output of the teamwork. Assuming that the groups function with all members' input (Guzzo & Shea, 1992) in forms of

expertise and experiences in the content area, teamwork and online learning, the highest and lowest individual means in each experience area were used independently as the group value for that area. These group values were then analyzed to test the null hypotheses.

### *Post-survey data analysis procedures*

The post survey was concerned particularly with the online collaboration experience during the problem solving process. It was constructed with three areas, teamwork, online learning, time and media, and related attitudes. The areas of teamwork and online learning were composed of 13 statements with Likert scale that 1 being strongly disagree and 7 being strongly agree. Unlike the rest of the Likert-scaled questions, Question 11 was written with a negative implication, so the responses were adjusted with a math formula:  $(8 - \text{original response})$  to align with all the other data collected in these Likert-scaled questions. The aligned responses were analyzed for the purpose of this study. For each of the above-mentioned areas, the means were calculated and ANOVA was employed to test if there was significant difference between the two treatments (null hypothesis tested:  $TR1=TR2$ , with alpha set to .05).

Questions 14-15 were concerned with the time spent on collaboration (Question 14 on total time, and 15-II on time with various media) and varied media they might have used (i.e., email, Cyberstats forum, phone, etc.). ANOVA was employed to test if there were significant differences between the two treatments on total time, and time with each medium (null hypotheses tested:  $TR1=TR2$ , with alpha set to .05).

To investigate research question 3a, ANOVA was employed to test if there was significant difference in perception of online learning, as measured in the online learning question area, between the two treatments. Null hypothesis tested was:  $TR1=TR2$ , and the alpha value was set at .05.

To investigate research question 3b, data gathered from post-survey question 18 was analyzed, and Pearson's Chi-Square was employed to test null hypothesis:  $TR1=TR2$  with the alpha set at .05.

To investigate research question 3c, data gathered in Questions 14-15 was analyzed and ANOVA was performed to test the null hypothesis:  $TR1=TR2$ , with the alpha set at .05.

## **Chapter 4**

### **RESULTS AND DISCUSSION**

This chapter presents the results of the study from the data analysis of the experimental study and the two surveys. The results of the experimental study, in response to the two research questions (Questions 1 and 2) will be reported first. Then there will be a brief report on the external structuring efforts and moderation that happened in the ESM condition. And the survey data analysis results will be reported afterwards, and then a brief discussion of the related research questions will follow. At the end of the chapter there will be a summary of the findings as related to the null hypotheses tested in this study.

#### **The Experimental Study Results**

The purpose of the experimental study was to study the effects of the treatment (PC or ESM) on well-structured problem solving process and ill-structured problem solving process, respectively. Specifically, the data analysis was conducted to test the effects of the treatment (PC or ESM) on a) group problem solving process during a well-structured problem solving task (WP), b) group use of statistical knowledge (SK) in ill-structured problem solving; c) group use of strategic knowledge (ST) in ill-structured

problem solving; d ) communication (CM) in ill-structured problem solving; and e) group overall problem solving process in ill-structured problem solving (OIP).

ANOVA was employed to examine if there were significant differences between the treatment (PC or ESM) in a) well-structured problem solving process, b) SK of ill-structured problem solving, c) ST of ill-structured problem solving, d) CM of ill-structured problem solving, and e) the overall process of ill-structured problem solving (OIP). The results of the analysis were used to answer Research Questions 1-2.

### **Descriptive data**

Table 4.1 below presents the block randomization result of the collaborative groups. Other descriptive data will be reported later in this chapter as related to the different research questions and null hypotheses.

Table 4.1: Participants by Treatment

Treatment	Total number of groups	Number of 3-member groups	Number of 4-member groups	Number of 5-member groups	Number of 6-member groups
PC	33	6	18	9	0
ESM	39	7	28	3	1
Total	72	13	46	12	1

### **Well-structured problem solving:**

Table 4.2 below reports the descriptive data for well-structured problem solving process measured in this study.

Table 4.2: Descriptive Data for WPS

Treatment	N	Mean	Std. Deviation	Std. Error	Minimum	Max
PC	33	32.21	3.054	.489	26	39
ESM	39	37.12	1.930	.294	32	40
Total	72	34.78	3.521	.389	26	40

The descriptive data shows that the well-structured problem solving process scores ranged from 26 to 40 among all participants, from 26 to 39 in the PC condition, and from 32 to 40 in the ESM condition. ESM groups showed more consistent scores with standard deviation of 1.930 than the PC groups, which had a bigger standard deviation (3.054).

### ANOVA

Table 4.3 below presents the results of ANOVA.

Table 4.3: ANOVA for WPS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	493.271	1	493.271	77.258	.000
Within Groups	510.778	80	6.385		
Total	1004.049	81			

The ANOVA result was statistically significant ( $p=.000$ ). Together with the descriptive data in Table 4.2, this indicated that groups in the ESM condition achieved significantly higher process scores in well-structured problem solving than those in the PC condition. The results rejected the null hypothesis ( $TR1=TR2$ ) at the .05 level, and led to the answer to research question 1: the externally-moderated peer online collaboration



was more effective in promoting group problem solving process during well-structured problem solving, than the peer-controlled collaboration.

### **Ill-structured problem solving**

The group ill-structured problem solving was assessed with scores for each of the three areas, the use of statistical knowledge (SK), the use of strategic knowledge (ST), and communication (CM), and a total score (OIS) generated with different weights for each of the above areas. The following presents the analysis results for each area and then the overall scores.

#### ***Multivariate ANOVA***

Multivariate ANOVA was performed with the responses being SK, ST, CM and OIP, and the treatment (PC or ESM) being the factor. As shown in Table 4.4, the MANOVA results were statistically significant ( $F=3.430$ ,  $p<.05$ ). This means that there were some differences on at least one dependent variable (SK, ST, CM, and OIP). Thus further data analysis was conducted and reported for each of the variables.

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Table 4.4: summary of multivariate analysis of variance (MNOVA) results

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MANOVA effect and dependent variable	Multivariate F Ho:df=4
Treatment group effect	Pillai's Trace 3.430( $p=.014<.05$ )
SK	
ST	
CM	
OIP	

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*Statistical knowledge (SK)*

Table 4.5 Descriptive Data for SK

Table 4.5: Descriptive Data for SK

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PC	35	2.83	.785	.133	1	4
ESM	38	3.45	.555	.090	2	4
Total	73	3.15	.739	.087	1	4

The descriptive data above shows that the group use of statistical knowledge reflected in the ill-structured problem solving ranged from 1 to 4 among all participants, from 1 to 4 in the PC condition, and from 2 to 4 in the ESM condition. The mean was 2.83 in the PC condition, and 3.45 in the ESM condition.

## ANOVA for Statistical knowledge in IPS

Table 4.6 ANOVA for SK

Table 4.6: ANOVA for SK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.976	1	6.976	15.304	.000
Within Groups	32.366	71	.456		
Total	39.342	72			

The ANOVA was significant ( $p=.00$ ). Together with the above descriptive data, this indicated that groups in the ESM condition achieved significantly higher scores, than those in the PC condition, in the use of statistical knowledge reflected in the ill-structured

problem solving process. The results rejected the null hypothesis ( $TR1=TR2$ ) at the .05 level, and led to the answer that the externally-moderated peer online collaboration was more effective in developing group use of statistical knowledge reflected in ill-structured problem solving than the peer-controlled condition.

### *Strategic Knowledge (ST) in ill-structured problem solving*

#### Descriptive Data for the Use of Strategic Knowledge in IPS

Table 4.7 reports the descriptive data for ST in the following.

Table 4.7: Descriptive data for ST

Treatment	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PC	35	2.77	.731	.124	1	4
ESM	38	3.32	.620	.101	2	4
Total	73	3.05	.724	.085	1	4

The descriptive data above showed that the use of strategic knowledge reflected in the ill-structured problem solving ranged from 1 to 4 among all participants, from 1 to 4 in the PC condition, and from 2 to 4 in the ESM condition. The mean was 2.77 in the PC condition, and 3.32 in the ESM condition, and 3.05 overall.

#### ANOVA for the Use of Strategic Knowledge in IPS

Table 4.8 reports the ANOVA for ST in the following.

Table 4.8: ANOVA for ST

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.399	1	5.399	11.837	.001
Within Groups	32.382	71	.456		
Total	37.781	72			

The ANOVA was significant ( $p=.001$ ). Together with the above descriptive data, this indicated that groups in the ESM condition achieved significantly higher than those in the PC condition in the use of strategic knowledge reflected in the ill-structured problem solving. The results rejected the null hypothesis ( $TR1=TR2$ ) at the .05 level, and led to the answer that the externally-moderated peer online collaboration was more effective in promoting group use of strategic knowledge reflected in ill-structured problem solving, than the peer-controlled condition.

### *Communication in IPS*

Table 4.9 reports the descriptive data for communication in IPS

Table 4.9: Descriptive Data for Communication in IPS

Treatment	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PC	35	2.40	1.006	.170	0	4
ESM	38	3.37	.786	.127	2	4
Total	73	2.90	1.016	.119	0	4

The descriptive data above showed that the communication reflected in the ill-structured problem solving ranged from 0 to 4 among all participants, from 0 to 4 in the PC condition, and from 2 to 4 in the ESM condition. The mean was 2.40 in the PC condition, and 3.37 in the ESM condition, and 2.90 overall.

## ANOVA for Communication in IPS

Table 4.10 reports the ANOVA for Communication in IPS in the following.

Table 4.10: ANOVA for Communication in IPS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.087	1	17.087	21.193	.000
Within Groups	57.242	71	.806		
Total	74.329	72			

The ANOVA was significant ( $p=.00$ ). Together with the above descriptive data, this indicated that groups in the ESM condition achieved significantly higher levels of communication than those in the PC condition in communication as reflected by the ill-structured problem solving rubric. The results rejected the null hypothesis ( $TR1=TR2$ ) at the .05 level, and led to the answer that the externally-moderated peer online collaboration was more effective in promoting communication reflected in ill-structured problem solving than the peer-controlled condition.

### *Overall Process in IPS*

Table 4.11 Descriptive Data for overall process in IPS

Table 4.11: Descriptive Data for overall process in IPS

Treatment	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PC	35	71.14	18.072	3.055	25	100
ESM	38	85.00	12.840	2.083	50	100
Total	73	78.36	16.957	1.985	25	100

The descriptive data above showed that the overall process of the ill-structured problem solving ranged from 25 to 100 among all participants, from 25 to 100 in the PC

condition, and from 50 to 100 in the ESM condition. The mean was 71.14 in the PC condition, 85.00 in the ESM condition, and 78.36 overall.

ANOVA for overall process in IPS

Table 4.12 reports ANOVA for overall process during IPS in the following.

Table 4.12: ANOVA for overall process in IPS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3498.454	1	3498.454	14.438	.000
Within Groups	17204.286	71	242.314		
Total	20702.740	72			

The ANOVA was significant ( $p=.00$ ). Together with the above descriptive data, this indicates that groups in the ESM condition achieved significantly higher than those in the PC condition in the overall problem solving process during ill-structured problem solving. The results rejected the null hypothesis ( $TR1=TR2$ ) at the .05 level, and led to the answer that the externally-moderated peer online collaboration was more effective in promoting overall group problem solving process during ill-structured problem solving than the peer-controlled condition.

Based on all the analysis results above regarding ill-structured problem solving, it was evident that the ESM condition was more effective in promoting group ill-structured problem solving, in group use of strategic knowledge, group use of strategic knowledge, communication and overall process, than the PC condition.

To develop better understanding of the above statistical findings, the following briefly reports what actually happened in each of the conditions, PC and ESM.

### **Peer-controlled Collaboration: What Happened in the PC condition**

Groups assigned to the PC condition were required to collaborate in a private, peer-controlled online forum, to which only members of the group had access. No moderator was assigned. No moderation or structuring efforts were provided from outside of the group in any of the group collaboration forums in this condition.

### **External Structuring and Moderation: What happened in the ESM condition**

To develop better understanding of the above statistical findings, the following briefly reports the structuring and moderating efforts that were actually provided by the instructor during the course of the online collaboration, followed by a brief discussion on how these efforts may have influenced the problem solving process in the ESM condition.

Both the instructor and the researcher were monitoring the group online activities closely. They were in close contact with each other and they discussed about their independent observation of the group activities frequently. They shared their thoughts on the needs for external moderation based on their own observations, and the instructor made independent decisions on how to address these needs as he thought appropriate.

The instructor served all groups assigned to the ESM condition as the moderator, behaving in accordance with the recommendations, which were described in Chapter 3. The instructor never gave any direct answers to specific statistics-related questions. The moderating efforts were delivered through online forum to the groups and/or private emails to individuals, as appropriate. All messages from the moderator, on Cyberstats or

by email, were written in a conversational style in order to foster student participation (Ahern, Peck, & Laycock, 1992). The instructor assisted with non-statistics issues only and never gave direct answers to statistic questions. Examples of the structuring and moderation efforts are reported in the following.

### **Structuring efforts**

The major structuring efforts were about the team contract. The moderator requested all groups in the ESM condition to construct a group contract through collaborative team efforts, and asked them to abide by the shared agreements once they all endorsed the contract. The message from the instructor was posted on the private forum for each group in the ESM condition (39 messages in total). Private emails were also sent to all individuals assigned to the ESM condition (154 in total) to request that they participate in the team contract building process. The messages read as the following:

“Subject: Team Contract

Hi,

I wanted to suggest that you should develop a team contract, or alike, before you start working on the group projects. Please discuss with your group members how you plan to work on this assignment and how to handle possible disagreements, etc. In your team contract, please try to answer the following questions:

Will you all share the responsibilities? If so, how?

Will each one of you contribute to the assignment? If so, how?

What will you do when there are different ideas and opinions?

What will you do if the communications through CyberStats become irrelevant to the group assignment?

Please post your team contract here on CyberStats.

Good luck with your projects!”



The ESM groups responded to the above message, and some groups worked out a very impressive team contract through collaborative efforts from all members. The instructor then followed up with those groups with compliments. To assist those groups that did not know how to start with a team contract, the instructor emailed them an example contract, with consent from the group that built this contract. The same message was also posted on their private group forum at Cyberstats. Many groups developed and posted a complete written team contract to their own forum. Some groups started negotiating a team contract on the forum but did not compile all the ideas together into one complete written contract. But even for the groups without a complete written contract, they posted the discussions to the forum, and discussed and decided together whether or not to endorse the suggestions from their peers. Basically they discussed the questions raised by the instructor together and reached shared commitment.

In the team contract, the groups addressed how they would take different roles and responsibilities during the problem solving process, and how they planned to address the differences and disagreements, and how they would build a healthy, professional relationship through shared efforts.

The contract building efforts have served the groups with several benefits at different levels. First, the activity of building such a contract stimulated the thoughts and discussions on their individual roles and responsibilities and guided the students to construct shared norms in the group. In addition to assisting the groups develop through the forming and norming stages, such efforts also pushed the groups to become prepared for possible issues and problems during the collaborative problem solving process. With the pre-determined agreements, or even just the pre-discussion on the possible issues, it

was more likely that the groups would be able to handle these issues and problems should they occur. The pre-determined, group-generated agreements may also have smoothed the collaboration process, and prepared the groups to work effectively as a whole. More importantly, the written contract, when posted on Cyberstats, was visible to all members all the time, and it could then remind the members of their commitment, responsibilities and the group norms, constantly. Therefore the contract itself may also have served as a powerful moderating force during the course of peer collaboration. In addition, the groups in the ESM condition then may have become able to moderate their own peer collaborations according to the team contract built by themselves. It was evident that many groups in the ESM condition were able to perform internal moderations as some group members saw the needs and took the role as a moderator. The most frequent internal moderations happened in the ESM condition were about motivation, scheduling, and task progress.

### **Moderation regarding task progress**

During the first few days, there was very little active collaboration regarding the problem solving tasks, and most messages at Cyberstats forums then were limited to the roles and responsibilities, and communication arrangements. The instructor posted a message on the private group forums for all ESM groups (39 in total) to urge them to make more progress on the team task. Many groups responded to the message then with discussions on the strategies to complete the problem solving tasks, and discussions on the timeframe and project progress as well. Later in the process, the instructor sent

another message to remind all the ESM groups of the timetable and checked the progress the groups had made. These moderation messages were not only nice, friendly reminders of the timeframe, but also served the groups as a motivator and urged them to make more active progress to complete the team tasks.

### **Moderation on problem solving strategy and communication**

Many groups appeared to be confused about how to interpret or address the problem solving tasks. The following message was responding to questions and inquiries the instructor received:

“As part of your write-up on Problem 1, you should indicate the rationale for your choice of physical measurements to look at: why did you choose the particular ones you describe? Also, try to make your report ‘interesting’—anything that might catch a reader’s attention. Imagine, for example, that you are submitting your ‘article’ to a magazine or newspaper—what can you report that might surprise readers?”

In Problem 2, make sure you justify what you chose to analyze. Also, put yourself in the Park Ranger’s shoes and determine what he would (or should) tell visitors. Think of what visitors might like to know.”

The messages above served as meta-cognitive scaffolding as Hannafin et al (1999) classified. It guided the students to think about the strategy and communication in problem solving, which were assessed for the ill-structured problem solving Process. The message provided stimulating questions for the groups to think about for statistics problem solving, and helped them to understand the communication aspect of the tasks as well. In fact, many groups failed to report the strategies they might have employed during ill-structured problem solving and lost credits for the use of statistical knowledge, strategic knowledge and/or communication as a result. For example, some groups simply

reported the regression equation in the ill-structured problem solving task, without justifying why they decided to do so and why it was relevant to the problem. The assessment of the ill-structured problem solving in this study emphasized not only the content knowledge, but also the problem solving strategy and communication reflected in the problem solving process. The above message from the instructor reminded the students to think critically about their statistic decisions, and asked them to justify these decisions appropriately. Such a message from an authority like the instructor must have significant impact on the group problem solving process and the groups' final writings of the project as well. Two similar meta-cognitive moderation messages were posted to the ESM group forums. A few, more similar moderation efforts were also provided via private emails to individual students.

### **Moderation regarding the tools in the learning environment**

Since the learners were all new to the web-based courseware, many did not notice the resources and tools available there. The instructor posted a message regarding some of the tools available there to every private forum in the ESM condition (in total 39 messages on Cyberstats). The message read as the following:

“There are quite some resources you may find useful at cyberstats when working on your project. check them out!

Calculators available at cyberstats:  
[http://statistics.cyberk.com/cyberstats/r\\_calcindex.cfm](http://statistics.cyberk.com/cyberstats/r_calcindex.cfm)

There's also a formula index page on cyberstats, where you can access all the formulas you may need to use for your projects:  
[http://statistics.cyberk.com/cyberstats/r\\_formulaindex.cfm](http://statistics.cyberk.com/cyberstats/r_formulaindex.cfm)”

The message above served as procedural scaffolding as Hannafin et al (1999) defined. Such moderation was particularly important when a new, comprehensive courseware was first introduced to learners, as learners may not locate these useful tools and resources on their own, and thus may not be able to take advantage of them. Cyberstats, as a comprehensive courseware integrated a lot of useful information and resources; however, due to the complexity of the interface design, some resources were located in a deeper layer in the file structure, and learners, who may be overwhelmed with the new software already, had a good chance to overlook some of the available resources. Thus when the instructor observed that no groups used the tools, he posted the above moderating message. The groups responded with excitement, such as “Do not forget the resource links that Chief put on cyberstats, they are helpful!!!!” (Message ID: 1808).

### **Moderations focusing on motivation**

One of the major moderating efforts was to motivate the group in the online collaboration process. In addition to constantly checking the task progress, the instructor also provided motivational moderations by recognizing the groups that showed active online collaboration, and encouraging the others for more active participation at the same time. For example, the instructor posted messages like the following on the collaborative forums on Cyberstats to the groups that constructed an impressive team contract:

“I wish to compliment you as a group for an excellent job in discussing and constructing a team contract. Keep it up!” (Message ID: 1642)

The motivational messages may have promoted a positive dynamic throughout the collaboration process, and thus helped smooth the process as well. It was evident that these messages also served as a model to some groups as they provided similar moderations later, internally, to maintain a positive atmosphere in the problem solving process. For an example, a member posted the following message at Cyberstats after they had accomplished a major task:

“Subject: almost there  
hey girls,  
just wanted to say we r working great together in lab, I really liked how we all pulled together and added to the thought process of #2. I think the suggestions we had are a great ending for that question! keep it up!”

### **The half-time phenomenon**

The researcher observed an interesting half-time phenomenon, which was similar to Gersick’s (1989) finding with work groups. During the first week of the problem solving process, few groups showed active collaboration in the online forums, and the groups that did communicate then were mostly concerned about the role and responsibility and scheduling. There was very little discussion on the team task itself. After the half-time point, starting from the very first day of the second week, the groups became more active in the online forums, and the discussions were heavily surrounding the problem solving tasks in the second half of the timeframe. This observation was consistent to Gersick’s findings of the dramatic change of group dynamics from the half-time point in organizational settings.

The dramatic change of the group dynamics at the half-time point also resulted in the different needs for external moderation. During the first half of the timeframe, the needs for external moderation were mainly about motivation and structuring. Once past the half-time point, as the groups proceeded aggressively with the problem solving tasks, the needs for moderation then changed to cognitive, strategic, meta-cognitive and procedural scaffolding that were closely related to the team task itself.

As a summary, the external structuring and moderating efforts served multiple purposes. First of all, these efforts provided cognitive, meta-cognitive, strategic and procedural scaffoldings during the collaborative problem solving process. Second, they addressed the psychological needs for the students to feel connected with the instructor/moderator. Third, they served as good, easy-to-model examples of moderation, and enabled the online groups to moderate the peer collaboration process on their own as needed.

### **The Survey Results**

Two surveys were conducted in this study. The pre-survey was intended to gather data regarding individual learners' prior experiences in the three areas, statistics, teamwork and online learning. This data was analyzed to generate a learner profile and to examine the effects of the prior experiences on group problem solving.

The post-survey was intended to gather data regarding individual learners' experiences in this particular online collaborative problem solving process, and their related attitudes. This data was analyzed to investigate research questions 3a, 3b, and 3c.

The data analysis methods and procedures followed the description in the previous chapter.

### **Pre-survey data analysis results**

The pre-survey data analysis results are reported in the following gathered into two parts, the learners' profile and the differences in past experiences, followed by a brief summary of the results regarding the effects of past experiences on group problem solving processes.

#### **Difference in past experiences**

As shown in Table 4.13, individual learners participating in this study did not have a strong background in statistics in the past, with an overall mean of 3.47 out of 7. They did not have a strong background in online learning, either, with an overall mean of 3.16 out of 7. Compared to the pre-mentioned two areas, the learners had relatively more positive experience with teamwork in general with an overall mean of 4.88 out of 7, which was a little over the neutral point of 4.

There was no significant difference in learners' prior statistics experience or online learning experience between the two treatments; however, there was a significant difference in teamwork experience between the two treatments, with those in the ESM condition having more general positive experiences in the past than those in the PC condition.



Table 4.13: Question area means and standard deviation for the pre-survey

Area by Treatment	N	Mean	Std. Deviation	F	Sig.
Statistics Experience				1.420	.235
PC	121	3.52	.654		
ESM	141	3.43	.526		
Total	262	3.47	.589		
Teamwork Experience				6.088	.014
PC	120	4.68	1.281		
ESM	140	5.06	1.193		
Total	260	4.88	1.247		
Online Learning Experience				.183	.669
PC	120	3.18	.730		
ESM	140	3.14	.699		
Total	260	3.16	.712		

Note: Cronbach Alpha reliability values: Statistics Experience=.5454; Teamwork Experience=.8201; Online Learning Experience=.6359.

In order to further understand the difference between the two treatments in teamwork experiences, chi-square was performed for responses to each question (i.e., questions 7, 8, 9 and 10) in that question area. The cross-tabulation in Table 4.14 shows that most of the students (236 out of 262) had prior teamwork experiences. There was no significant difference ( $p=.405$ ) between the treatment in terms of number of students with prior teamwork experiences.

Table 4.14: responses to Question 7 by treatment

Response by treatment	Question 7: Have you had teamwork experiences in college before taking Stat200?			Total
	Yes	No		
Treatment	PC	111	10	121
	ESM	125	16	141
	Total	236	26	262

$P=.405$

Table 4.15 shows the descriptive data for responses to Question 8: “my teamwork experiences have been pleasant in general”. The data shows that in general the students reported that their teamwork experiences were positive, slightly above the neutral point (4 of 7). The overall mean was 4.92 out of 7, and 4.79 in PC condition, 5.02 in ESM condition.

Table 4.15: Descriptive data for Question 8: “my teamwork experiences have been pleasant in general”

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	120	4.79	1.414	.129	4.54	5.05	1	7
ESM	140	5.02	1.344	.114	4.80	5.25	1	7
Total	260	4.92	1.378	.085	4.75	5.08	1	7

Table 4.16 shows that the ANOVA was not significant ( $p=.181$ ) at the .05 level. Thus there was no significant difference between the treatments in terms of how pleasant their teamwork experiences were.

Table 4.16: ANOVA for Question 8

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.411	1	3.411	1.801	.181
Within Groups	488.727	258	1.894		
Total	492.138	259			

Table 4.17 shows the descriptive data for responses to Question 9: “I find teamwork helpful with my course projects”. The data shows that in general the students reported that teamwork was helpful with their course projects, with an overall mean

slightly above the neutral point (4 of 7). The overall mean was 4.82 out of 7, and 4.58 in PC condition, 5.03 in ESM condition.

Table 4.17: Descriptive data for responses to Question 9: “I find teamwork helpful with my course projects”

treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	120	4.58	1.470	.134	4.32	4.85	1	7
ESM	140	5.03	1.469	.124	4.78	5.27	1	7
Total	260	4.82	1.483	.092	4.64	5.00	1	7

Table 4.18 shows that the ANOVA was significant ( $p=.016$ ) at the .05 level. This result indicated that overall students in the ESM condition found teamwork more helpful than those in the PC condition.

Table 4.18: ANOVA for responses to Question 9

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.809	1	12.809	5.933	.016
Within Groups	557.052	258	2.159		
Total	569.862	259			

Table 4.19 reports the descriptive data of the original responses to Question 10: “I find teamwork difficult in general”. The results show that students in general did not report that their teamwork experiences in the past were difficult, with an overall mean of 3.08, 3.33 in PC condition and 2.87 in ESM condition.

Table 4.19: Descriptive data for responses to Question 10: “I find teamwork difficult in general”

Treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	120	3.33	1.600	.146	3.04	3.62	1	7
ESM	140	2.87	1.372	.116	2.64	3.10	0	7
Total	260	3.08	1.497	.093	2.90	3.27	0	7

The ANOVA shown in Table 4.20 was significant at the .05 level ( $p=.013$ ). This result indicates that students in the ESM condition found teamwork less difficult than those in the PC condition.

Table 4.20: ANOVA for responses to question 10

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.786	1	13.786	6.280	.013
Within Groups	566.352	258	2.195		
Total	580.138	259			

Based on the above analysis results, there was no difference between the treatments in terms of how many students had had prior teamwork experiences. The differences between the two treatments regarding prior teamwork experiences existed in the value and difficulty of teamwork, and not in the perceived pleasantness of their teamwork experience.

### Effects of Past experiences on problem solving

To investigate research question 4 about the effects of learners’ related past experiences on varied group problem solving processes, the highest and lowest means in

a group in each area (i.e., prior statistics experience, prior teamwork experience and prior online learning experience), were tested, because they were hypothesized as the two most likely predictors on the group problem solving scores (i.e., WP, SK, ST, CM, OIP). The scatter plots of each area of the prior experiences (stats, teamwork, or online learning), either the highest (statsMax, TeamMax, OnlineMax) or lowest (statsMin, TeamMin, OnlineMin) individual mean in a group, and any of the problem solving scores (WP, SK, ST, CM, or OIP) did not show any relations between any two of them. The regression models were tested using all the prior experiences, either the highest individual mean or the lowest in a group for each experience area, as predictor for each of the problem solving scores. None of the models showed a good fit. Thus the past experiences of the groups, reflected in the highest and lowest individual values of each group, did not influence the group problem solving processes as measured in this study.

Table 4.21: Summary of the regression using the lowest values

## ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.399	3	10.800	.827	.484(a)
	Residual	835.601	64	13.056		
	Total	868.000	67			
2	Regression	.132	3	.044	.076	.973(a)
	Residual	32.601	56	.582		
	Total	32.733	59			
3	Regression	1.813	3	.604	.998	.401(a)
	Residual	33.920	56	.606		
	Total	35.733	59			
4	Regression	.632	3	.211	.194	.900(a)
	Residual	60.768	56	1.085		
	Total	61.400	59			
5	Regression	197.313	3	65.771	.213	.887(a)
	Residual	17307.271	56	309.058		
	Total	17504.583	59			

## Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	30.714	4.035		7.612	.000
	StatMin	1.096	.904	.151	1.212	.230
	TeamMin	-.265	.425	-.076	-.623	.535
	OnlineMin	.843	.881	.119	.956	.342
2	(Constant)	3.268	.898		3.639	.001
	StatMin	-.060	.205	-.040	-.294	.770
	TeamMin	-.005	.092	-.007	-.053	.958
	OnlineMin	.063	.197	.043	.320	.750
3	(Constant)	1.630	.916		1.779	.081
	StatMin	.161	.209	.102	.774	.442
	TeamMin	.103	.093	.143	1.099	.276
	OnlineMin	.239	.201	.157	1.191	.239
4	(Constant)	3.217	1.226		2.623	.011
	StatMin	-.043	.279	-.021	-.154	.878
	TeamMin	.059	.125	.063	.471	.640
	OnlineMin	-.162	.269	-.081	-.603	.549
5	(Constant)	69.230	20.693		3.346	.001
	StatMin	.618	4.712	.018	.131	.896
	TeamMin	1.639	2.109	.103	.777	.440
	OnlineMin	.653	4.532	.019	.144	.886

**Note:****Model 1:**

a Predictors: (Constant), OnlineMin, TeamMin, StatsMin

b Dependent Variable: WP

**Model 2:**

a Predictors: (constant), OnlineMin, TeamMin, StatsMin

b Dependent Variable: SK

**Model 3:**

a Predictors: (constant), OnlineMin, TeamMin, StatsMin

b Dependent Variable: ST

**Model 4:**

a Predictors: (constant), OnlineMin, TeamMin, StatsMin

b Dependent Variable: CM

**Model 5:**

a Predictors: (constant), OnlineMin, TeamMin, StatsMin

b Dependent Variable: OIP

Table 4.22: Summary of the regression using the highest values

## ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	86.548	3	28.849	2.363	.079(a)
	Residual	781.452	64	12.210		
	Total	868.000	67			
2	Regression	1.819	3	.606	1.098	.357(a)
	Residual	30.914	56	.552		
	Total	32.733	59			
3	Regression	.564	3	.188	.299	.826(a)
	Residual	35.169	56	.628		
	Total	35.733	59			
4	Regression	.988	3	.329	.305	.821(a)
	Residual	60.412	56	1.079		
	Total	61.400	59			
5	Regression	758.458	3	252.819	.845	.475(a)
	Residual	16746.125	56	299.038		
	Total	17504.583	59			

## Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	21.798	5.638		3.866	.000
	StatMax	1.139	1.005	.140	1.134	.261
	TeamMax	.707	.566	.158	1.248	.217
	OnlineMax	1.167	.737	.199	1.583	.118
2	(Constant)	1.514	1.269		1.193	.238
	StatMax	.340	.224	.205	1.519	.134
	TeamMax	.161	.125	.179	1.282	.205
	OnlineMax	-.156	.180	-.119	-.865	.391
3	(Constant)	2.724	1.354		2.012	.049
	StatMax	.187	.239	.108	.785	.436
	TeamMax	-.035	.134	-.037	-.262	.794
	OnlineMax	-.050	.192	-.037	-.262	.794
4	(Constant)	1.883	1.774		1.061	.293
	StatMax	.150	.313	.066	.481	.632
	TeamMax	.156	.175	.126	.887	.379
	OnlineMax	-.134	.252	-.075	-.533	.596
5	(Constant)	54.844	29.538		1.857	.069
	StatMax	7.165	5.205	.187	1.377	.174
	TeamMax	1.996	2.921	.096	.683	.497
	OnlineMax	-4.374	4.194	-.145	-1.043	.302



Model 1:

a Predictors: (Constant), OnlineMax, TeamMax, StatsMax

b Dependent Variable: WP

Model 2:

a Predictors: (constant), OnlineMax, TeamMax, StatsMax

b Dependent Variable: SK

Model 3:

a Predictors: (constant), OnlineMax, TeamMax, StatsMax

b Dependent Variable: ST

Model 4:

a Predictors: (constant), OnlineMax, TeamMax, StatsMax

b Dependent Variable: CM

Model 5:

a Predictors: (constant), OnlineMax, TeamMax, StatsMax

b Dependent Variable: OIP

### **Post-survey data analysis results**

The following reports the data analysis results for the post-survey. The results are organized by the question areas, the teamwork experience, online learning, time and media, and attitudes and future preference.

#### **Results regarding teamwork (Questions 1-3)**

For each individual, the mean of their responses to questions 1-3 was calculated and analyzed as the mean of this question area. The responses to question 3 (“I find teamwork difficult in Stat200”) were reported after being aligned to be responses to a positive statement, as the rest of the survey (please refer to related section in Chapter 3 for details). Table 4.23 reports the means of the question area of teamwork by treatment. The individual learners reported positive experience in their teamwork in this course, with an overall mean of 5.16 out of 7, 5.15 in PC condition and 5.17 in ESM condition. Basically, the result shows that students in this study reported a positive teamwork

experience. There was no significant difference between the two treatments on individuals' reported teamwork experience in this study. ANOVA was also conducted to analyze data collected in each question as well, and there was no significant difference between the two treatments on any of the variables, with p values of .460, .567, and .359 respectively.

Table 4.23: Descriptive data for the question area of teamwork

treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	118	5.15	1.481	.136	4.88	5.42	1	7
ESM	140	5.17	1.378	.116	4.94	5.40	1	7
Total	258	5.16	1.423	.089	4.98	5.33	1	7

P=.912

### Results regarding Online learning experience

Questions 4-13 were about individuals' online learning experiences, measured with a Likert scale of 7, with 7 being the strongly agree and 1 being strongly disagree. Means were calculated to get an area value for each individual, and were then analyzed to examine if there was significant difference between the two treatments in this area. Data collected in questions 5 and 11 analyzed and reported after being aligned to be responses to a positive statement, as the rest of the survey (please refer to related section in Chapter 3 for detail)

***General post impression of online collaboration:***

The means of data gathered from questions 4-13 in the post-survey were calculated and analyzed, with alignment for some of them as appropriate, as the general impression of online learning post the research. Table 4.24 shows the ANOVA for the post impression of online learning was not significant ( $p=.149$ ) at the .05 level.

Table 4.24: ANOVA for post impression of online collaboration

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.601	1	2.601	2.096	.149
Within Groups	317.793	256	1.241		
Total	320.394	257			

The results in Table 4.24 show that there was no significant difference in individual learner's reported impression of online collaborative learning between the two treatments ( $p=.149$ ).

***Results regarding online learning in detail***

The questions on online learning were specifically about the difficulty of online learning (Questions 4 and 5), if they enjoyed it (Questions 6 and 7), if they enjoyed the online teamwork (Questions 8 and 9), the perceived value of online learning (Questions 10 and 11), and the perceived value of technology in the online collaboration (Question 12 and 13). Questions 4, 6, 8, and 12 were about the online learning experience in general, and Questions 5, 7, 9, 10, 13 were specifically about their online learning experiences in the course of this study, with the courseware Cyberstats. The following

reports the data analysis results in terms of learners' general experience and the particular experience of this online collaborative learning.

Table 4.25 reports the descriptive data and ANOVA for the reported general online learning experience (means of questions 4, 6, 8, and 12). In general the individual learners reported relatively negative experiences with online learning, with an overall mean of 3.8217 out of 7, and 3.9181 in PC condition and 3.7405 in ESM condition, all lower than the neutral point of 4. Also there was no significant difference between the two treatments in the reported online learning experience in general ( $p=.111$ ).

Table 4.25: Descriptive data and ANOVA for general online learning experience in the post-survey

treat ment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Mini mum	Maxi mum	F	Sig.
					Lower Bound	Upper Bound				
PC	118	3.9181	.92283	.08495	3.7498	4.0863	1.67	6.25		
ESM	140	3.7405	.86053	.07273	3.5967	3.8843	2.00	7.00		
Total	258	3.8217	.89223	.05555	3.7123	3.9311	1.67	7.00	2.552	.111

Table 4.26 below reports the descriptive data and ANOVA for the online experience in this study (means of questions 5, 7, 9, 10, and 13). In general the individual learners reported a relatively negative experience with online learning in this study, with an overall mean of 3.54 out of 7, and 3.65 in PC condition and 3.44 in ESM condition, all lower than the neutral point of 4. Also there was no significant difference between the two treatments in the reported online learning experience in general ( $p=.167$ ).

Table 4.26: Descriptive data and ANOVA for the reported online learning experience in this study

treat ment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Mini mum	Maxi mum	F	Sig.
					Lower Bound	Upper Bound				
PC	118	3.65	1.291	.119	3.42	3.89	1	6		
ESM	140	3.44	1.172	.099	3.25	3.64	1	7		
Total	258	3.54	1.230	.077	3.39	3.69	1	7	.192	.167

### Results regarding attitudes

To investigate research question 3, including all the four sub-questions, the data analysis results are reported in the order of the sub-questions in the following.

#### *Perceived difficulty of online collaboration*

The data in Table 4.27 shows that the majority of the individual learners (127 out of 181) did not feel collaboration was difficult. The chi-square tests suggest that there was significant difference between the two treatments, and more learners in the ESM condition, than the PC condition, reported online learning not difficult based on their experiences in this study. As the pre-survey results indicated, learners in this study did not report teamwork difficult in general, based on their prior experiences, and learners assigned to the ESM condition found teamwork less difficult compared to those in the PC condition. The post-survey data analysis indicates statistically significant difference

between the two treatments in learner's perceived difficulty of teamwork based on their experiences in this particular study ( $p=.039$ ). Given the difference in prior teamwork experience; however, the treatment may not be the only factor that led to this difference. Consistent with the existing literature (Johnson et al, 1987; Hooper, 1992; Ruberg, Moore & Taylor, 1996), the external moderations may have played an important role in smoothing the process of online collaboration for groups assigned to the ESM condition.

Table 4.27: Perceived difficulty of online collaboration by treatment

Q 16: Did you feel it was difficult to collaborate with your group members and /or other classmates when completing the group project for Stat200?			
Treatment	Total	Number of "yes"	number of "no"
PC	86	32	54
ESM	95	22	73
Total	181	54	127

$P=.039$

The second part of question 16, "why or why not" gathered some open-ended responses to help understand the reasons for their perceived difficulty of online collaboration. As mentioned above, most students reported that they did not find it difficult to collaborate with their team members. Those that reported it was not difficult to collaborate with their teams mentioned that a) they had a positive, friendly team, they got along with one another in the team and became friends; b) they found Cyberstats convenient to communicate ideas in writing; c) they were all contributing and helping each other; d) they used varied communication media as needed, thus they did not have to schedule frequent face-to-face meetings. For those who reported they did, the reasons were mainly the following: a) social loafing and free ride, little or no contribution from some members; b) less positive or productive team dynamics with some members not

being responsive or respectful; c) the delay of responses; d) technology problems, such as the failure of Internet access, difficulty of transmission and merging of files. These findings were consistent with the research on and practice in online learning as the challenges (the reasons for perceived difficulty) presented to learners and strategies to overcome them (reasons for perceived non-difficulty). The reported reasons for the difficulty of peer collaboration also confirmed the needs for external moderation, and they presented the typical moderation that could have made the process less difficult. These reasons, for either perceived difficulty or non-difficulty, all seem to confirm the four aspects of online collaborative learning as Zhang and Ge (2003) proposed: team task, team development, peer relationship, and communication media.

### *Perceived value of peer collaboration*

Table 4.28 below reports the perceived value of peer collaboration as on whether or not it was helpful with their group project. 104 out of 162 reported that they found it helpful, with 47 in the PC condition and 57 in the ESM condition. The Pearson chi-square test shows that there was no significant difference between the two treatments ( $p=.798$ ). Thus there was no significant difference of perceived value of peer collaboration between the two treatments. The null hypothesis is accepted at the .05 level, and leads to an answer to research question 3b: the different approach to online collaboration did not lead to differences in students' perceived value of online learning.

Table 4.28: Perception of the value of peer collaboration by treatment

Treatment	Q17: Do you think peer collaboration helped you study for the group project?		
	No	Yes	Total
PC	25	47	72
ESM	33	57	90
Total	58	104	162

P=.798

The second part of question 17, “why or why not” gathered some open-ended responses. As mentioned above, most students reported that peer collaboration helped them study. Those responded “yes” to this question mentioned the benefits of peer collaboration such as: a) it generated more ideas; b) it brought more, different perspectives; c) stimulated more self motivation; d) integrated varied expertise; e) peers helped with questions and clarified confusions/ mis-understanding; f) the disagreement, discussion and debate helped to build a deeper understanding as well as finding the right path to a solution; g) stimulated more sense of responsibility as they would share the same grade and everybody was held liable for it; and h) teamwork was valued highly in corporate.

Those reported that peer collaboration was not helpful with their study indicated the following reasons: a) they felt they could have done better alone, not in a group, either because they knew (or felt they knew) more than their peers in the group, or because they did not like teamwork in general; b) peer collaboration was time-consuming, and not so efficient; and c) they felt the group did not really collaborate but rather just splitting the job, so they were not able to see the whole picture as they would love to otherwise. The perceived values of peer collaboration, as reported above were certainly consistent with the literature on the benefits of collaborative learning, and they



confirmed the value of collaborative learning from learner's own experiences, and also confirmed the value of research like this one. The reasons for perceived non-value, on the other hand, indicated that a) learner differences may lead to different perceived value of collaborative learning, depending on what their expectations are and what they actually gained from the experience; b) the efficiency and time-effectiveness are two challenging things to achieve in online collaboration, and if not achieved, may decrease the perceived value of collaborative learning; c) when groups only cooperate instead of collaborate by chunking labor, it decreases the perceived value of peer collaboration. All these reasons, for perceived value or non-value of peer collaboration, were consistent to related literature as potential benefits (e.g., Harasim, 1990; Scardamalia & Bereiter, 1994; Blumenfeld, et al, 1996; Lin et al, 1999) and challenges (e.g., Harasim, 1990; Zhang & Harkness, 2001) for collaborative learning.

***Future willingness of using a similar tool for team assignment:***

As shown in Table 4.29, the majority (153 out of 262) responded to Question 18 (“In the future, if a similar online forum was available, would you choose to use it for a team assignment?”) with a negative answer, indicating that they may not choose to use a similar tool for team assignments. There was no significant difference in student's willingness to choose a similar tool in the future between the two treatments. The null hypothesis  $TR1=TR2$  was accepted ( $p=.232$ ) at the .05 level. Thus the approach to collaboration did not lead to significant difference in students' willingness of using a similar tool for team assignments.

Table 4.29: Descriptive data for future willingness of using a similar tool

Treatment	Q: 18: In the future, if a similar online forum was available, would you choose to use it for a team assignment?		Total
	No	Yes	
PC	76	46	122
ESM	77	63	140
Total	153	109	262

P=.232

The second part of question 18 (“why or why not”) gathered some open-ended data for response to the previous part of the question (“yes” or “no”). The reported reasons for not choosing a similar tool in the future were basically in the following four categories: technology-related problems or concerns, preference to other media, learner differences, and group dynamics.

Ten students reported that they or their group members encountered some technical problems with Cyberstats. These problems including a) the instability of the Internet; b) problems logging on to Cyberstats; c) the lack of file transmissions and file sharing functionality through Cyberstats; d) the less user-friendly interface of Cyberstats; e) tedious log in reminder; f) no easy access to a computer and/or the Internet. The technology-related reasons were concerned about the accessibility and reliability of Internet technology, and also the limitations of Cyberstats in terms of interface design and functionality. It reminds the researcher that we cannot assume easy access to the technologies it requires to collaborate online, in addition, the functionality and interface design of such comprehensive courseware may impact users’ attitudes toward similar software for collaborative learning.

The majority of responses mentioned the availability of other communication media that they may choose over a similar tool like the groupware available in

Cyberstats. They mentioned the face-to-face meetings, telephones, emails, instant messengers and Angel, a comprehensive course management system accessible for all students in this university. They would choose some of the other media mentioned above for one or more of the following reasons: a) some media are able to transmit more information at once, such as face-to-face meeting and telephone, compared to such a text-based forum; b) some other media can convey more perceived social presence during the course of collaboration, such as telephone and instant messenger; c) some medium was already familiar to other members, such as email and Angel. These reasons are all well explained by the rational media choice theories (i.e., media richness theory and social presence theory) as well as the social constructivist media behavior theories. Thus it confirms Zhang and Ge (2003)'s suggestion that the media choice for online collaborative learning environment should base on the rational understanding of characteristics of the communication media and a good understanding of the social context the target users reside in, in terms of the media choice and media behavior.

Another reported reason for not choosing such a tool in the future was the learner differences in terms of their learning style and technology readiness. A few of responses mentioned that they did not like online learning or group work, and/or technology (computer or Internet) in general. Some reported that they simply enjoy talking to people, literally, thus they would probably avoid using such an electronic communication tool if traditional face-to-face communication was possible at all. On the other hand, those reported being willing to choose a similar tool elaborated that they prefer online communications in general to traditional face-to-face meetings, and they were more comfortable talking online. Again, these responses are consistent with the literature on

the challenges (e.g., Zhang 2002; Zhang & Harkness, 2001) and benefits (e.g., Scardamalia & Bereiter, 1994; Blumenfeld et al, 1996; Lin et al, 1999) of computer-supported collaborative learning

Quite a few mentioned that their future choice would depend on the group dynamics. More specifically, their media choice would depend on the accountability of the members and the relationships among peer collaborators. Again, these responses seem to support Zhang and Ge's (2003) theoretical framework to look at online collaborative learning from the inter-related dynamics among team task, group development, peer relationship and communication media.

### *Time, Media and Treatment*

Table 4.30 reports the descriptive data for "Total Time on Collaboration" (Question 14). There was no significant difference in the total time learners spent on the collaborative tasks between the two treatments ( $p=.263$ ). Thus the two approaches to online collaboration did not lead to different amount of total time spent on the tasks. It indicated that the EMS condition, which was found to be more effective in promoting group process in varied problem solving tasks, did not demand more time.

Table 4.30: Descriptive data for "Total Time on Collaboration"

Treatment	N	Mean	Std. Deviation	Minimum	Maximum
PC	119	142.74	110.996	7	600
ESM	139	160.99	140.529	7	980
Total	258	152.49	127.707	7	980

P= .263

The data results related to the time spent with the different media the learners had chose to use for collaboration and communication are displayed in Table 4.31, which reports the communication media and time by treatment. Table 4.31 shows the data was extremely skewed to the right, with maximum values much greater than the means. Therefore a nonparametric test, Mann-Whitney 2-sample test for equality of medians was performed.

Table 4.31: Communication media, time by treatment

Communication Medium	Treatment	N	Max	Mean	Minimum	Std Deviation
Emails with Team	PC	119	30	6.52	0	5.922
	ESM	139	40	6.29	0	6.327
	Total	258	40	6.40	0	6.133
Email instructor/TA	PC	118	20	1.73	0	2.797
	ESM	139	20	1.29	0	2.704
	Total	257	20	1.49	0	2.750
Face-to-face Meetings	PC	115	5	1.94	0	1.372
	ESM	137	6	1.83	0	1.287
	Total	252	6	1.88	0	1.325
Meeting Time*	PC	116	480	66.57	0	80.415
	ESM	139	300	77.55	0	72.006
	Total	255	480	72.55	0	75.992
Cyberstats Forum Time*	PC	118	150	36.17	0	32.219
	ESM	139	200	37.25	0	38.092
	Total	257	200	36.75	0	35.452
Total number of Phone Calls	PC	118	35	1.58	0	4.621
	ESM	139	20	1.19	0	2.845
	Total	257	35	1.37	0	3.763
Phone Time*	PC	119	100	4.37	0	12.179
	ESM	138	60	4.38	0	9.207
	Total	257	100	4.37	0	10.665
Time with Other Media	PC	118	200	15.81	0	37.331
	ESM	139	475	18.17	0	56.758
	Total	257	475	17.08	0	48.732

Table 4.32 reports the Mann-Whitney U test for the time with different media by treatment. There were no significant differences between the treatments in the time spent with any medium.

Table 4.32: Mann-Whitney Test

Communication Medium	Treatment	N	Mean Rank	Sum of Ranks
Emails with Team	PC	119	132.01	15709.50
	ESM	139	127.35	17701.50
Email instructor/TA	PC	118	136.44	16099.50
	ESM	139	122.69	17053.50
Face-to-face Meetings	PC	115	129.70	14916.00
	ESM	137	123.81	16962.00
Meeting Time*	PC	116	119.95	13914.00
	ESM	139	134.72	18726.00
Cyberstats Forum Time*	PC	118	130.10	15352.00
	ESM	139	128.06	17801.00
Total number of Phone Calls	PC	118	129.65	15298.50
	ESM	139	128.45	17854.50
Phone Time*	PC	119	126.09	15004.50
	ESM	138	131.51	18148.50
Time with Other Media	PC	118	131.84	15557.50
	ESM	139	126.59	17595.50

Test Statistics(a)

Test	Email within group	Email instructor/TA	Face-to-face meeting	Meeting time in minutes	Cyberstats forum time	No. of phone calls	Phone time in minutes	Time with other media
Mann-Whitney U	7971.500	7323.500	7509.000	7128.000	8071.000	8124.500	7864.500	7865.500
Wilcoxon W	17701.500	17053.500	16962.000	13914.000	17801.000	17854.500	15004.500	17595.500
Z	-.503	-1.654	-.661	-1.599	-.221	-.163	-.727	-.767
Asymp. Sig. (2-tailed)	.615	.098	.508	.110	.825	.871	.467	.443

a Grouping Variable: Treatment

### Summary of hypotheses tested

The following is a brief discussion on the null hypotheses tested in this study.

*Hypothesis1: There will be no significant difference of the means of group problem solving process during well-structured problem solving between peer-controlled online collaboration groups and externally-moderated online collaboration groups.*

The above null hypothesis was rejected at the .05 level. The results showed that groups in the externally-moderated condition demonstrated better group problem solving process during well-structured problem solving than those in the peer-controlled condition, as measured in this study. Thus the externally structured and moderated peer online collaboration was more effective in promoting group problem solving process during well-structured problem solving as measured in this study, compared to the peer-controlled condition.

*Hypothesis2: There will be no significant difference of the means of group problem solving process during ill-structured problem solving between peer-controlled online collaboration groups and externally-moderated online collaboration groups.*

The above null hypothesis was rejected at the .05 level, showing that groups in the externally-moderated condition achieved better scores in all the three sub-areas of ill-structured problem solving process as well as the overall problem solving process as measured in this study. Groups in the externally-moderated condition demonstrated better use of statistics knowledge, better use of strategic knowledge and higher level of communication in the ill-structured problem solving process. Thus the externally structured and moderated peer online collaboration was more effective in promoting group problem solving process during ill-structured problem solving. More specifically,

the externally-moderated condition was more effective in promoting group use of statistical knowledge, group use of strategic knowledge and communication in the ill-structured problem-solving process.

*Hypothesis3a: There will be no significant difference in students' perceived difficulty of peer online collaboration between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.*

The above null hypothesis was rejected at the .05 level. There was a significant difference between the treatments in students' perceived difficulty of peer collaboration. More students found peer collaboration not difficult in the ESM condition as compared to the PC condition.

*Hypothesis3b: There will be no significant difference in students' perceived value of peer collaboration between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.*

The above null hypothesis was accepted at the .05 level. There was no significant difference between the two treatments in students' perceived value of peer collaboration. The reported perception of the value of peer collaboration was positive in general, meaning that the majority of students found it helpful.

*Hypothesis3c: There will be no significant difference in students' willingness to use a similar tool in the future between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.*



The above null hypothesis was accepted at the .05 level, showing no significant difference in students' willingness of using a similar tool in future between the two treatments. About half of the participants reported that they would not choose to use a similar tool, and there was no significant difference between the treatments. This was not consistent with a previous study in a similar setting (Zhang & Peck, 2003). The open-ended data reported the following reasons: technology-related problems or concerns, preference for other media, learner differences, and group dynamics. Thus media choice, as reported in this study, was not an isolated, individual decision, but rather a response to the needs for varied levels of communication, media characteristics, learner differences, and the social context. The approach to online collaboration, external moderated or peer-controlled, alone, did not lead to a significant difference of students' media choice between the treatments.

Hypothesis3d: *There will be no significant differences in the means of the time spent on collaboration or the use of different media for collaboration between those in the peer-controlled collaboration groups and those in the externally moderated collaboration groups.*

The results supported the above null hypothesis regarding the total time spent on the problems, as well as the time spent with each medium they reported. This indicated that the external moderation, while it helped reach better group problem solving process as measured in this study, did not require more time during the collaboration process.

In summary, the two different approaches to online collaboration did not lead to differences in students' perception of the value of peer collaboration, or their willingness to use a similar tool for team assignment, but they led to significant differences about the

perceived difficulty of peer collaboration. More students in the ESM condition found peer collaboration not difficult, as compared to those in the PC condition. The different approaches did not lead to significant differences in the time spent on the collaborative problem solving. The different treatments did not lead to differences in the time spent on any of the media they had used, including the online forum.

*Hypothesis4: Students' prior experiences (e.g., statistics background, teamwork experiences, and online learning experiences) lead to no differences in the group problem solving processes.*

The graphs and the linear regression models tested all suggested that students' prior experiences in any of the areas, represented by either the highest or the lowest value in a group, did not lead to any difference in any group problem solving processes as measured in this study. The null hypothesis was accepted. Thus students' prior experiences with statistics, teamwork, and online learning did not lead to difference in the group problem solving processes as measured in this study.

The scatter plots did not show a strong relationship between any of the past experience areas and any of the problem solving processes. The regression models using either the highest or lowest group value of all the prior experience areas did not appear to be a good predictor for any of the problem solving scores. In this study students' past experiences did not lead to differences in the group problem solving processes.

In general this study had mixed findings on the effects of the two approaches to online collaboration (PC or ESM). It was evident that external structuring and moderation resulted in better group problem solving processes in both well-structured problem solving and ill-structured problem solving, which confirmed the researcher's earlier

findings (Zhang, 2003). However, the findings did not confirm some of the previous research on related attitudes (Zhang & Peck, 2003). The following chapter will discuss the findings as related to the field of instructional design and online collaborative learning, and make suggestions for future research.

## Chapter 5

### GENERAL DISCUSSION

#### Overview of the Findings

The primary purpose of this study was to investigate the relative benefits of two online collaboration approaches, peer-controlled and externally-moderated, on group problem solving processes during well-structured problem solving and ill-structured problem solving. The secondary purpose was to investigate the relative effects of these two approaches on individual learners' related attitudes and perceptions. The well-structured problem solving process was assessed with pre-determined scoring criteria, and ill-structured problem solving process was measured from the three areas of statistics problem solving, use of statistical knowledge, use of strategic knowledge, and communication. An overall ill-structured problem solving score was generated by combining the weighted scores for these three areas. The related attitudes and perceptions were measured by individual surveys, and the means in different question areas were analyzed as appropriate to answer the related research questions. In addition, this study investigated the effects of prior experiences with statistics, teamwork, and online learning on the varied problem solving process measures. In these cases, the highest and lowest means of a group for each question area were analyzed separately. The findings related to the four research questions are summarized below, and followed by discussions of the implications for instruction, instructional design and future research.

1. Externally-moderated online collaboration was more effective, when compared to peer-controlled approach, on group problem solving process during well-structured problem solving, as measured with the scoring rubric used in this study.

This finding confirmed previous research (Zhang, 2003; Zhang & Peck, 2003) on the effects of the two conditions on group problem solving. In the ESM condition, the instructor provided structuring efforts and external moderation to the groups, as needed. The structuring efforts, which mainly focused on the group contracting, provided a strategy for the groups to work out shared agreement and commitment on collaboration. In the contract, and/or the process of building a contract, the teams discussed and specified the varied roles and responsibilities, stated how they agreed to handle disagreements and different opinions, and specified their commitment to the task in writing. With such discussions, it was more likely that these groups would, and could collaborate more effectively as they follow the written agreement. Such efforts may have also helped generate and maintain a positive team dynamic by reducing possible “free riding” and social loafing through the binding power of the team contract. The positive group dynamics, as Bosworth and Hamilton (1994) pointed out may have contributed to learner performance in collaborative learning. This finding lends some support to researchers’ suggestion that online learning should be moderated to be effective (Hamm & Adams, 1992; Flannery, 1994).

2. Externally moderated online collaboration was more effective, when compared to the peer-controlled approach, on group problem solving process with the ill-structured problem, as measured with the rubrics used

in this study. The differences were significant in all three areas of the ill-structured problem solving process, as measured with the rubrics used for this study: use of statistical knowledge (ST), use of strategic knowledge (SK), and communication (CM). Differences in the overall process score were also statistically significant.

The results showed that external moderation, provided by the instructor in a role of a moderator in this study, had positive effects on group process and problem solving strategies in ill-structured problem solving. The moderation efforts led to better utilization of problem solving strategies and more effective communication, as measured by the use of strategic knowledge (SK) and communication (CM) in this study. Researchers (Harasim, 1990; Hamm & Adams, 1992, Bosworth & Hamilton, 1994) stressed the importance of moderating peer collaboration for effective learning. Bernard et al (2000) also suggested the instructor should play the role of a moderator or facilitator in online learning. The findings of this study again confirmed a previous study on the effects of the two approaches to online collaboration during both types of problem solving (Zhang, 2003). These findings also extended the findings in the above research (Zhang) with more in-depth investigations on the three aspects of statistical problem solving. The finding helps to answer not only whether or not external moderation was more effective during ill-structured problem solving process, but also in which aspects the effects were present.

3. External structuring and moderation did not result in more time spent on the collaborative problem solving process for the students in the ESM condition than those in the PC condition.

4. External moderation led to differences in students' perceived difficulty of peer collaboration between the two treatments, with more students in the ESM condition than those in the PC condition reporting that peer collaboration was not difficult.

The structuring efforts together with other moderations may have contributed to the reported non-difficulty of peer collaboration in the ESM condition in this study. This finding is consistent with the literature (Hooper, 1992; Ruberg, Moore & Taylor, 1996) that suggests that an external moderator can smooth the process of collaboration. The team contract, in particular, appears to have led the groups to think about the possible issues they might face as a group through the course of collaboration and provided an opportunity for them to work out a shared agreement on how they plan to complete the tasks. It may have stimulated the members of a group to be better prepared for the possible issues and problems, such as disagreements, roles and responsibilities. Such effort helped the groups to become aware of the possible difficulties waiting ahead for successful collaboration, and pushed them to specify their personal commitment to the group task in writing. Therefore through the course of collaboration, they could always refer to the team contract on how to handle the teamwork, especially when something negative or less pleasant happened. It also became a structuring protocol for the groups to use as a guide for their collaborative problem solving. Inconsistent with a previous study in a similar context (Zhang & Peck, 2003), this study did not find difference in students' reported future willingness to use a similar tool for collaboration. Zhang and Peck found that students in the moderated condition reported that they were more likely to choose to use a similar collaborative tool for future team assignments, yet it was not confirmed in

this study. The participants' responses to the survey may have indicated that their responses to that particular question were not necessarily based on the group collaboration tool but rather the entire learning experience with the web-based courseware they were introduced to for the first time. The survey results shed light on design issues of such courseware as well as similar group collaboration tool. These implications will be discussed in the later part of this chapter.

5. Past experiences with statistics, teamwork, and online learning did not lead to difference in problem solving processes.

Instead of median or mean, the researcher used the highest and lowest values of the past experiences in a group, separately, as indicators of the group experiences, to investigate research question 4. Participants' past experiences did not lead to any differences in problem solving processes, as indicated in this study.

### **Implications for Instructors**

The structuring and moderating efforts, which did not directly relate to the problem solving task itself or the content knowledge it required, resulted in significant differences in group problem solving process in terms of strategies and processes as measured with the rubrics used in this study. The significant effects of external moderation performed by the instructor in this study strongly support the literature on the changed role of an instructor in an online collaborative learning environment (Hamm & Adams, 1992; Flannery, 1994; Bernnard et al, 2000). During the collaborative problem solving process, the instructor played the role of moderator, rather than a traditional role



of a “teacher” or a “knowledge giver”. His role was mainly to facilitate collaboration, stimulate thinking, and motivate participation, as suggested by researchers (e.g., Brown & Plinscar, 1989; Hamm & Adams, 1992; Bosworth & Hamilton, 1994; Brandon & Hollingshead, 1999).

The structuring efforts, mostly related to the team contract, may have smoothed the collaboration process, and helped the groups to build a shared understanding and commitment toward the team task. The team contract may have also served as a macro strategy for the groups to handle teamwork. Some groups reported the advantages of having such a document available before they stepped into the team tasks. The efforts of building a team contract and the consistent applications of the contract may have prepared the groups to address the typical issues and challenges in peer collaboration through joint commitment. In the practice of peer collaboration, online or in person, team contract may prove to be a strong, powerful strategy to help the teams build shared understanding of teamwork and collaboration, thus helping to smooth the collaboration process. The structuring and moderating efforts may have also served as easy-to-learn models for the online groups, and some groups in the ESM condition demonstrated good internal moderation as the students saw the needs.

The half-time phenomenon as noticed in this study and previous research (Gersick, 1988) also shed some light into the moderation strategies. During the first half of the timeframe the needs for moderation are mainly about motivation and scheduling. In the second half of the timeframe, however, the groups become more conscious about the timetable and make more aggressive progress toward the tasks. Then during this period of time, the moderation efforts are expected to be related to the team task itself

(for example, problem solving strategies) rather than the team process (for example, communication strategies or motivational messages). Being aware of the possible different needs for moderation associated with time, the instructor can be better prepared for the role of a moderator for online collaborative groups.

Another important implication for instructors working with problem solving is related to assessment for such non-traditional learning tasks. When different scoring rubrics focused on the product of the problem solving rather than the process were used by the course instructor, the results were very different. Preliminary findings indicate that when assessed in a more traditional, product-oriented way, the control group may even have outperformed subjects in the experimental condition. The grading criteria used for the ill-structured problem solving in this study were heavily concerned with the strategies and processes of problem solving. All the aspects of the ill-structured problem solving task, including use of statistical knowledge, were evaluated in the context of problem solving. In addition to the problem solving strategies and processes, instructors will no doubt find it important to evaluate the mastery of certain content knowledge as well. The grading rubrics used in this study did not assess content knowledge in separation from the problem solving process. For instructors who are equally concerned about problem solving and content knowledge mastery, the grading rubrics used in this study, which focused more on the problem solving process and strategies than content knowledge mastery may not be the most appropriate assessment tool. By the same token, if the instructor is mostly concerned about students' mastery of certain content knowledge, an ill-structured problem solving task may not be necessary nor the most appropriate. For example, if the instructors want to see if the groups know how to do a regression, then the

problem solving strategies or processes may not be important in the assessment, and another more traditional assessment tool may serve the purpose better.

The researcher has also informally observed from the online discourse that those in the treatment condition with external moderation appeared to have demonstrated more activities in defining the problem, searching the paths to solve the problem, and evaluating possible solutions. It appears to the researcher that the moderation efforts helped the learners to view the assignment as a problem solving task rather than a typical, traditional “assignment.” Several groups in the treatment condition tried to locate other resources to help solve the problem and did not limit themselves to the given dataset. When learners took the problem solving approach they interpreted and defined the problem more broadly than a typical statistic analysis task. Some groups realized that there could be more than one solution, and generated recommendations from different perspectives in addition to appropriate statistic analysis. On the other hand, groups in the control condition seemed to take a more traditional approach to complete this assignment. Some of them did not start with defining the problem, but appeared to be guessing what content knowledge the instructor might want to assess with this assignment. As they noticed that regression was covered around the time this project was assigned, they decided that this project must be about regression. For these groups in their report on the assignment there was no justification for doing a regression or why they chose certain variables. In these cases, their grades were not good when evaluated from the problem solving perspectives used in this study’s rubrics. However, using a more traditional assessment tool, they might have received better grades. Since it is possible that students reach a valid solution to a problem by guessing or by accident, the researcher thinks that

it is important to evaluate the performance of problem solving not only by the final solution but also the reasoning and justifications of the process and strategies as to how they reach such a solution. It could be challenging for instructors to keep a good balance between process and outcome in the evaluation.

In addition, since the ill-structured problem solving was the very first task of its kind for the participants in this study, there was probably a learning curve with problem solving. Groups in the treatment condition may have benefited from the external structuring and moderating efforts with such a learning curve; however, at the same time they seemed to have spent more time and effort defining the ill-structured problem compared to the peer-controlled groups, and thus might not be able to stay more focused on the content knowledge itself. In this study the external moderations were mostly concerned about the problem solving strategies, teamwork process, etc., and did not involve any content knowledge, as defined by the scope of the study. For instructors implementing collaborative problem solving; however, they might want to keep a good balance between process and content, especially at the early stage when learners are coping with the learning curve of problem solving as well as the challenging content knowledge. As learners become more and more experienced with problem solving and/or other types of higher order learning tasks, the needs for moderation may change to more content oriented, and instructors may need to change the focus of the moderation efforts accordingly.

### **Implications for Media Selection in Instructional Design**

Students' responses to some of the post-survey questions indicate a strong need for a better designed groupware for collaboration, and such groupware should be consistent with the tools they are already familiar with. For example, many reported that they would prefer Angel to Cyberstats for future team collaboration. Angel was a similar, comprehensive course management system available for all students in that university and used in most courses by the time the study was implemented. The reason for their preference was that other students around them used it, and people were familiar with it already, yet Cyberstats was something new to the students as well as to the social contexts they were in. Such media preference is well aligned to the social constructivist media theory (i.e., Fulk, Schmitz & Steinfield, 1990; Fulk, 1993), which suggests that users' media choice and media behaviors are subject to the social context they reside in. So for the design of an online collaborative learning environment, the selection of communication media should not only be consistent to the task requirements but also aligned with the social context the users reside in (Zhang & Ge, 2003).

The students reported a relatively less positive experience with the courseware used in this study. As related to the collaborations for problem solving, many commented that they wanted to have immediate feedback from others, especially when working on the ill-structured problem, and there were strong needs sometimes for perceived social presence of other members in the online collaboration process. Therefore they used instant messenger or would prefer it if available. The reported needs for a richer medium and/or a medium that conveys strong social presence were results of the complexity of

the tasks they were engaged in. When designing for higher-order learning tasks, like in this study, the learning environment should provide appropriate communication medium/media as required by the nature of the learning tasks.

Zhang and Ge (2003) proposed to look into the dynamics of online collaborative learning from all the four perspectives, team task, group development, peer relationship and communication media. They suggested that in the design and facilitation of online collaborative learning, instructors and instructional designers should be aware of not only the media characteristics from the rational media choice theories (i.e., media richness theory and social presence theory), but also the social context's influence on the media behaviors. Such understanding can explain phenomena like those reported in this study, and can help make good recommendations and decisions in terms of what media should be provided and how would the varied media accommodate the team tasks.

### **Implications for collaborative groups**

External moderation, as provided in this study, should serve as scaffolding, which eventually lead to similar moderating efforts from the inside of the groups. The team contract, for example, is a strategy the learners can use without having to have an external moderator to make it happen, if the instructors have made them aware of the strategy well enough. Also, the moderation provided by the instructor can be performed by some group members, when they see the need and take the responsibility to moderate the online collaboration process. Training is needed to prepare them for possible moderation efforts. If learners can use the list of guidelines for moderation, external or

internal, to consciously monitor their own group collaboration, they may be able to consciously moderate the process by themselves. Some groups demonstrated good, effective internal moderation as this study proceeded. It would be highly rewarding if all collaborative groups wean from external moderation and grow with increasingly effective internal moderation. Many of the external moderations provided by the instructor in this study are easy to model, and collaborative groups can benefit from moderating themselves in the learning process.

### **Implications for Future Research**

This study confirmed previous research on the effects of the two moderation approaches on problem solving (e.g., Zhang, 2003; Zhang & Peck, 2003), and extended the findings with more detailed investigations. However, these studies were not able to answer specifically *how* these differences happened in terms of group achievement and collaboration process. A naturalistic inquiry is needed to explore the collaboration process, and seek deeper understanding of the “*hows*” accordingly. To investigate the “*hows*”, two different methods might be used: one is a similar experimental study with valid assessment of the online collaboration process in addition to the group achievements; the other is a naturalistic inquiry to explore the “*hows*” in the real setting as the collaboration is progressing together with a descriptive analysis and a discourse analysis of the online discussions.

The study confirmed previous findings regarding well structured problem solving (Zhang & Peck, 2003) and the two types of problem solving (Zhang, 2003). Because

different tasks may generate different needs for moderation (Zhang & Ge, 2003), the effects of the same approach on other types of task may vary. It would be worth pursuing to investigate the relative effects of the two approaches to online collaboration on other types of team tasks as well, such as discussion, decision making and production. It would also be interesting to investigate if similar effects exist in different content areas.

As this study was primarily interested in peer collaboration and group performance, it did not investigate individual learning outcomes. However, the group performances may not necessarily reflect the possible effects of the two approaches on individual learning and individual performance. For individual learners, the effects might be more or less in terms of individual problem solving processes and outcomes. For future research, studies looking at both group and individual achievements may be able to better reflect the overall effects of the two approaches to peer online collaboration on problem solvings, and other higher-ordered learning outcomes, at both the individual and group levels.

To understand the dynamics, research needs to look at all the aspects of online collaborative learning simultaneously, the team task, the group, and the media (Zhang & Ge, 2003). The research initiated some interesting findings regarding the relationships between team tasks and communication media, and between group dynamics and media. It provides a starting point for future empirical studies to further investigate the relationships among them.



### **Limitations of the study**

This study was implemented in a hybrid course, yet by design the investigation was mainly limited to the online group activities through the web-based courseware. The study examined the online collaborative problem solving in a hybrid course; however, the researcher was not able to investigate the learning activities in the computer labs or the group activities through other media. Although limited time was allocated to the students during the lab sessions for the problem solving tasks, it would probably have been a very good setting to observe the team dynamics, which were reportedly related to some attitudes in the post-survey data. Similarly, the groups utilized other communication media when working on the problems, but the research itself by design was limited to the online forum only. Thus the treatment differences only existed in the online forums, and the researcher did not know if similar moderation happened when the groups utilized other media. So the findings were limited to a certain extent. In addition, as the participating groups were required to use the group forum built in the web-based courseware, this may have weakened the ecological validity of the study.

In this study, individuals formed self-selected groups first, and then the groups were randomly assigned to one of the treatments. In theory, a true randomization would have been randomly assigning individuals into one condition, and then forming groups in each condition. The two treatments did not have exactly the same number of groups of the same size, thus group size was not well controlled as a possible factor in the study.

In terms of grading, the two graders graded each group submission of the ill-structured problem for use of statistics knowledge, use of strategic knowledge, and

communication in that order. Thus their grading of one aspect of the ill-structured problem solving, for example, use of statistical knowledge, may have influenced the grading of the following aspect(s) of the same problem solving task, for example the strategic knowledge and/or communication. It would have been better if the graders had only graded one aspect of the ill-structured problem solving task for all groups at a time, this way the grades for the different aspects of the same groups' ill-structured problem solving may have been more reliably independent from one another.

In retrospect, the surveys used in this study were not the best instruments to measure the perception of online collaborative learning and related attitudes. Some question items were not written in the same positive tone as the rest of the survey. A better designed survey or other instrument may have strengthened the power of the study on some of the research questions examined through the surveys. The post-survey used in this study, grouped questions regarding online learning, online technology, teamwork online, etc. all into one question area, online collaborative learning. Such grouping reflected the different aspects of online collaborative learning; however, without a scientific integration of the varied aspects, without an appropriate weighting for each aspect, such instrument might have blurred the relationship among them, and thus weakened the power to justify the findings.

The data gathered in these open-ended questions in the surveys provided some helpful information to understand the reported attitudes, but it was not sufficient to answer the "why" questions in detail. A more robust data collection method, such as interview, would gather richer data and enable the researcher to answer the "whys" with

more details, and would help build a deeper understanding of the issues and problems underlined.

Due to practical reasons, the groups in this study were engaged in the two types of different problem solving tasks at the same time, and the online collaboration was related to both of them most of the time. Thus the moderations were not necessarily for only one type of problem solving, and may or may not have addressed the possibly different needs for moderation required by the different team tasks.

Also as related to the fact that both ill-structured problem solving and well-structured problem solving were assigned to the groups at the same time, some groups, as the researcher has observed from their online discourse, was working on the well-structured problem solving first, and the ill-structured problem solving later. Such order may have influenced their performance on the ill-structured problem solving task, as they may have learned how to do a problem solving task from doing the well-structured problem solving first. On the other hand, there were groups working on both tasks at the same time, and thus they may not have benefited from the learning by doing process as some other groups. Unfortunately the sequence of the two types of problem solving task was not controlled or studied in this particular research process.

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## Appendix A: the well-structured problem

### Stat 200 Sections 5-8 Group Project 2

Due Oct. 28, 2003

#### Directions:

This project is to be completed by members of your group. All members of a group will get the same score. Delegate responsibilities to get the job done, but be sure to check over the whole report because your score is for the whole report.

**Submit a typed group report with a cover page** that indicates each member's name, last four digits of social security number, group number, section number, **and a signature for each member**. The signature affirms that the person actually participated.

#### Part 1:

As a class activity in Stat 200, data were obtained on students in the class, including

gender (C1)

age (C2)

physical measurements

height (C3) and ideal height (C4)

weight (C5) and ideal weight (C6)

length of left (C7) and right (C8) forearms

length of left (C9) and right (C10) foot

width of the left (C11) and right (C12) hand

span from little finger to end of thumb on left (C13) and right (C14) hands

two measurements of head circumference (C15 and C16)

distance around chest (C17)

length of left (c18) and right (c19) arm

waist (c20)

longer finger: ring or index (C21)

handedness: left or right (C22)

race (C23)

hair color (C24)

eye color (C25)

eye color most attracted to (or by) (C26)

feature in another person most attracted to (C27)

view of one's weight (C28)

number of days per month one has at least 2 beers (C29)

number of parties one goes to per month (C30)

number of times per week one exercises (C31)  
GPA (C32)  
credit load (C33)  
number of hours one studies per week (C34) The results are contained in the dataset  
“Student Characteristics”.

Please use the above data set to investigate the following questions.

A. People often say that males and females differ in bodily characteristics. What does the data tell us in that regard? Please support your statement with appropriate data analysis and follow with a brief summary of your analysis and conclusion.

B. Based on the given data, do you think people differ in bodily characteristics by race? Why or why not?

C. What’s the difference between actual and ideal weights for both males and females?

D. Please examine and summarize the relationship between two of the categorical variables that have exactly two values. Then estimate the percentage of students having one of the possible values of the response and obtain the 95% conservative margin of error for it.

### **Appendix B: The Ill-Structured Problem**

“Old Faithful Geyser in Yellowstone National Park, Wyoming, derives its name and its considerable fame from the regularity (and beauty) of its eruptions. As they do with most geysers in the park, rangers post the predicted times of eruptions on signs nearby, and people gather beforehand to witness the show. A park geologist collected 107 measurements on the durations of Old Faithful eruptions and intervals until subsequent eruption. The data is stored in the file named ‘Old Faithful’.

You are called in as a statistician to examine "Old Faithful" and to prepare an article reporting on it reflecting what you know as a ‘statistician’. Based on “Old Faithful”, what are the suggestions you may provide to visitors to ensure their safety?”

### Appendix C: Assessment Tool for the well-structured problem

#### Part A: total 20

- i. Selected at least 3 quantitative variables to describe (1 point each, total up to 3)
- ii. Interpretation of descriptive statistics and/or graphs:  
Specified differences between females and males on each of the selected three variables (2 points for each correctly described difference, 0 point for each incorrectly described difference, total up to 6) and provided supporting evidence for the statements, which could be descriptive statistics and/or graphics pertaining to the variables (up to 6 points total, 2 points for each supporting evidence)
- iii. Conducted correlations, R-Sq, scatter plots that reflected strength of relationships (1 point for each, up to 3).
- iv. Summary: the differences are ‘huge’ and it is obviously so (2 points for correct interpretation and 0 for incorrect or lack of interpretation)

#### Part B: total 20 (same as Part A)

- i. Selected at least 3 quantitative variables to describe (1 point each, total up to 3)
- ii. Interpretation of descriptive statistics and/or graphs:  
Specified differences between females and males on each of the selected three variables (2 points for each correctly described difference, 0 point for each incorrectly described difference, total up to 6) and provided supporting evidence for the statements, which could be descriptive statistics and/or graphics pertaining to the variables (up to 6 points total, 2 points for each supporting evidence)
- iii. Conducted correlations, R-Sq, scatter plots that reflected strength of relationships (1 point for each, up to 3).
- iv. Summary: the differences are ‘huge’ and it is obviously so (2 points for correct interpretation and 0 for incorrect or lack of interpretation)

#### Part C: total 5

- i. Obtained the descriptive statistics and report means, medians, or trimmed means for actual and ideal weights, by gender (2 points for including 2 or 3 of the above, 1 point for including 1 of them, 0 point if not by gender)
- ii. Interpreted or described the differences (3 points for correct and thorough interpretation or description of all the differences; 2 points for correct interpretation or description of most of the differences; 1 point )

#### Part D: total 5

- i. Specified explanatory and response variable with gender being an explanatory variable; handedness or longfing being either response or explanatory ( 1 point for correct identification of both explanatory and response variables, 0 point for incorrect identification)
- ii. Calculated row percents and discussed relationship (2 points for providing row percents and correct interpretation of the relationship; 0 point for incorrect interpretation and/or no row percents)
- iii. Provided Confidence Interval for one value of the response variable (2 points).

**Appendix D: Scoring Rubric for the ill-structured problem**

area	Score level	Characteristics
<p>The use of statistical knowledge:</p> <p>Knowledge of statistical principles and concepts which result in a correct solution to a problem.</p>	4	<p>Shows thorough understanding of the problem's statistical concepts and principles, with investigations of the relationships among all the variables in the database, and is able to eliminate the irrelevant variable(s) through statistical tests</p> <p>Uses appropriate statistical terminology with no misunderstanding or misinterpretation of the terms</p> <p>Executes appropriate statistical analysis and interprets the results correctly</p> <p>Generates recommendations pertaining variability of intervals and other reasonable safety considerations</p> <p>Generates additional thoughts, such as identifying other possible relevant variables, and provide suggestions for the park ranger to collect data and make predictions accordingly</p>
	3	<p>Shows nearly complete understanding of the problem's statistical concepts and principles with one or two missing aspects of the problem, with investigations of the relationships among most of the variables in the database, and is able to eliminate the irrelevant variable(s) through statistical tests</p> <p>Uses nearly correct statistical terminology and notations, with minimal (less than 2) misunderstanding or misinterpretations of the statistical terminology and notions;</p>



		Executes statistical analysis completely, analysis is generally correct but contains minor errors, which do not lead to significant errors of problem solution(s)
	2	Shows understanding of some of the problem's statistical concepts and principles, with investigations of the relationships among some of the variables in the database, and is able to eliminate the irrelevant variable(s) through statistical tests  Contains serious statistical errors or misunderstanding /mis-interpretation of some statistical terms
	1	Shows very limited or no understanding of the problem's statistical concepts and principles, and is not able to eliminate irrelevant variable(s) through appropriate statistical tests;  Fail to use statistical terms;  Makes major statistical errors (e.g., choosing the wrong variables as the explanatory, or using inappropriate analysis techniques)
	0	Shows no understanding of the problem's statistical concepts and principles.
The use of Strategic knowledge:	4	Identifies all the important elements of the problem and shows a thorough understanding of the relationships among them;  Reflects the employment of an appropriate and systematic strategy for solving the problem (e.g. how to eliminate irrelevant variables and find the appropriate variables for further analysis; or being able to test assumptions, hypotheses and making justifications accordingly);  Gives clear evidence of a solution process, and solution process is complete and systematic, including complete and thorough evaluation of possible solutions.
Identification of important elements of the problem, and the use of models, diagrams, symbols and	3	Identifies the most important elements of the problems and shows general understanding of the relationships among them;

/or algorithms to systematically represent and integrate concepts.		Solution process is nearly complete, may not include a thorough evaluation of all possible solutions.
	2	Identifies some important elements of the problems but shows only limited understanding of the relationships among them;  Gives some evidence of a solution process, but the strategies employed are not appropriate (such as randomly conducting different statistic tests without testing the assumptions beforehand, and/or without evaluation of the possible solutions .
	1	May attempt to use irrelevant outside information;  Fails to identify important elements or places too much emphasis on unimportant elements;  Reflects an inappropriate strategy for solving the problem;  Gives incomplete evidence of a solution process; solution process may be missing, difficult to identify or completely unsystematic.
	0	Fails to indicate which elements of the problem are appropriate; No evidence of employing a strategy in the problem solving process.
Communication:  Written explanation and rationales that translate into words the steps of the solution	4	gives a complete, clear, unambiguous written explanation of the solution process employed; explanation addresses both <u>what</u> was done and <u>why</u> it was done; includes appropriate and complete diagrams, charts, and other MiniTab outputs, as applicable, to illustrate the relationships; Presents strong supporting arguments which are logically sound and complete; Communicates effectively to the identified audience, tourists in this case, with easy to understand language when explaining the analysis and results.
	3	gives a nearly complete written explanation of the solution process employed; clearly explains what was done and begins to address why it was done; Includes most of the appropriate diagrams, charts, and MiniTab outputs to

<p>process and provide justification for each step. Though important, the length of response, grammar and syntax are not the critical elements of this dimension.</p>		<p>illustrate the relationships;  Presents supporting arguments which are logically sound but may contain some minor gaps;  Generally communicates effectively to the identified audience, tourists in this case, with a few unexplained jargons;</p>
	2	<p>Makes significant progress towards completion of the problem, but the explanation or description may be somewhat ambiguous or unclear;  gives some written explanation of the solution process employed, either explains what was done or addresses why it was done;  explanation is vague or difficult to interpret, though;  includes some diagrams, charts or MiniTab outputs, yet some of them were flawed or unclearly explained;  Argumentation may be incomplete or may be based on logically unsound premise;  Explanations were somewhat vague or difficult to understand by the target audience, tourists in this case.</p>
	1	<p>Has some satisfactory elements but fails to complete or may omit significant parts of the problem;  explanation or description may be missing or difficult to follow;  fail to explain what was done and why it was done;  May include a diagram which incorrectly represents the problem situation, or diagrams are not explained or irrelevant.</p>
	0	<p>Communicates ineffectively, words do not reflect the problem;  May include diagrams which completely misrepresent the problem situation.  Little or no written explanation or justification of the solution process or solution.</p>

Adapted from Lane (1992).

## Appendix D: Pre-Survey

Last 4 digits of your student ID: \_\_\_\_\_

Group ID: \_\_\_\_\_

Number of members in your group: \_\_\_\_\_

Part 1: Please tell us a little about your **statistics-related experiences** by answering the following questions.

**DIRECTIONS:** The statements below are designed to identify your related experiences with statistics. Each item has 7 possible responses. Please read each statement. Mark the **one** response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

- |   |                      |   |   |   |   |   |                |
|---|----------------------|---|---|---|---|---|----------------|
|   | Very poorly          |   |   |   |   |   | Very well      |
| 1. How well did you do in your high school mathematics courses?                                   | 1                    | 2 | 3 | 4 | 5 | 6 | 7              |
|   | Very poor            |   |   |   |   |   | Very good      |
| 2. How good at mathematics are you?   | 1                    | 2 | 3 | 4 | 5 | 6 | 7              |
|   | Not at all confident |   |   |   |   |   | Very confident |
| 3. How confident are you that you can master introductory statistics material?                    | 1                    | 2 | 3 | 4 | 5 | 6 | 7              |
| 4. Number of <u>years</u> of high school mathematics taken: _____                                 |                      |   |   |   |   |   |                |
| 5. Number of college mathematics <u>courses</u> completed (don't count this semester): _____      |                      |   |   |   |   |   |                |
| 6. Number of statistics courses completed (include A/P if taken—don't count this semester): _____ |                      |   |   |   |   |   |                |

Part 2: Please tell us about your **teamwork experiences** by answering the following questions.

**DIRECTIONS:** The statements below are designed to identify your teamwork experiences. Questions 8-10 each have 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). **If you have no opinion or no teamwork experiences, choose response 4.** Please read each statement. Mark the **one** response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response.

Record your answer and move quickly to the next item. Please respond to all of the statements.

7. Have you had any teamwork experiences in college before taking Stat200?

Yes

No

	Strongly disagree			Neither disagree nor agree			Strongly agree
8. My teamwork experiences have been pleasant in general.	1	2	3	4	5	6	7
9. I find teamwork helpful with my course projects.	1	2	3	4	5	6	7
10. I find teamwork difficult in general.	1	2	3	4	5	6	7

Part 3: Please tell us about your **online learning experiences** by answering the following questions.

**DIRECTIONS:** The statements below are designed to identify your online learning experiences. Questions 11-19 each have 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). **If you have no opinion or no online learning experiences, choose response 4.** Please read each statement. Mark the **one** response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

	Strongly disagree			Neither disagree nor agree			Strongly agree
11. I find online learning difficulty in general.	1	2	3	4	5	6	7
12. I enjoy online learning activities in general.	1	2	3	4	5	6	7
13. I enjoy working in a group on the internet.	1	2	3	4	5	6	7
14. I find the online learning activities helpful with my coursework.	1	2	3	4	5	6	7
15. I feel that the online learning activities are some extra work I have to do.	1	2	3	4	5	6	7
16. I think the internet technology has made teamwork easier than it is otherwise.	1	2	3	4	5	6	7
17. Number of courses taken completely on the internet: _____							
18. Number of courses taken that have some components on the internet: _____							
19. Number of courses taken that involve online group work: _____							

**Thank you very much for your participation!**

## Appendix E: Post Survey

Last 4 digits of your student ID: \_\_\_\_\_

Group ID: \_\_\_\_\_

Number of members in your group: \_\_\_\_\_

Part 1: Please tell us about your **teamwork experiences on the past two projects** by answering the following questions.

**DIRECTIONS:** The statements below are designed to identify your teamwork experiences. Each item has 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). **If you have no opinion, choose response 4.** Please read each statement. Mark the **one** response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

	Strongly disagree			Neither disagree nor agree			Strongly agree
1. My teamwork experiences in Stat 200 have been pleasant.	1	2	3	4	5	6	7
2. I find teamwork helpful with my course projects in Stat 200.	1	2	3	4	5	6	7
3. I find teamwork difficult in Stat 200.	1	2	3	4	5	6	7

Part 2: Please tell us about your **online learning experiences** by answering the following questions.

**DIRECTIONS:** The statements below are designed to identify your online learning experiences. Items 4-15 each have 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). **If you have no opinion, choose response 4.** Please read each statement. Mark the **one** response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

	Strongly disagree			Neither disagree nor agree			Strongly agree
4. In general, I find online learning difficult.	1	2	3	4	5	6	7

5. I find it difficult to learn statistics through Cyberstats.
6. In general, I enjoy the online learning activities. 1 2 3 4 5 6 7
7. I enjoyed the online learning activities in Cyberstats. 1 2 3 4 5 6 7
8. In general, I enjoy working in a group on the Internet. 1 2 3 4 5 6 7
9. I enjoyed working with my group in Cyberstats. 1 2 3 4 5 6 7
10. I find the learning activities in Cyberstats helpful with Stat 200. 1 2 3 4 5 6 7
11. I feel that the online learning activities in Cyberstats were some extra work I had to do. 1 2 3 4 5 6 7
12. I think the Internet technology has made teamwork easier than it is otherwise. 1 2 3 4 5 6 7
13. Working with my group through Cyberstats was easier than it would have been otherwise. 1 2 3 4 5 6 7

14. As an individual, how much time did you spend on peer collaboration to complete the group project? Please include all the time you spent on discussion with your group member(s), including on the Cyberstats group forum, on the phone, out class meeting, via email, etc.

\_\_\_\_\_ minutes approximately

**DIRECTIONS:** Item 15 below is composed of two parts, I and II. For Part I, in the left column, please circle the letter(s) before the choice(s) of your response; please choose all that apply; for Part II, in the right column, please write your response to the choices on the left in corresponding spaces in the blank line.

15-I: In what activities did you participate to collaborate with your team? Please select all that apply in the following.	15-II: If you select the item listed in the corresponding left column, please answer the question(s) listed below.
15-I-a: Emailing team member(s) regarding the group project	15-II-a: How many emails did you send to or receive from your group members regarding the group project?  _____
15-I-b: Emailing the instructor and/or the TA regarding the group project?	15-II-b: How many emails to and from the Instructor and/or the TA did you receive

	and send regarding the group project? _____
15-I-c: Face-to-face meeting	15-II-c: How many meetings did you have for the purpose of this group project?  _____  15-II-c2: How much time was spent in the meeting(s)?  _____ minutes approximately
15-I-d: Using the online forum provided	15-II-d: How much time did you spend on the online forum for this group project?  _____ minutes approximately
15-I-e: Collaborating with team members on the phone	15-II-e: How many phone calls did you make and receive regarding this group project?  _____  15-II-e2: How much time did you spend on the phone calls for the purposes of this group project?  _____ minutes approximately
15-I-f: Other (please specify):	15-II-f: How much time on activities listed in the left column?  _____ minutes approximately

16 Did you feel it was difficult to collaborate with your group members and/or other classmates when completing the group project for Stat 200? Why or why not?



17 Do you think peer collaboration helped you study for the group project? Why or why not?

18 In the future, if a similar online forum was available, would you choose to use it for a team assignment? Why or why not?

19 Given a choice among the alternatives given below, which would you recommend be chosen in the future?

- a Use of textbook only, at a cost of around \$85.
- b Combined use of a text and Cyberstats, at a total cost of around \$115.
- c Use of Cyberstats only (no text), at a cost of around \$30.

**Thank you very much for your participation!**

### Appendix F: Validation tool

The following validation tool will be used to ensure the problems are classified correctively as either well-structured or ill-structured.

Project__ Question __		
	Expert Evaluation	Comments
Is the goal(s) of the problem clearly stated or specified?	Yes somewhat no	
Is it true that all the needed information to reach the final solution is clearly identified or described?	Yes somewhat no	
Is it true that there is only one correct solution to this problem?	Yes somewhat no	
Is it true that there is only one correct way to reach the final solution to this problem?	Yes somewhat no	
Is the project relevant to the course (Stat200 Elementary Statistics)?	Yes somewhat no	
Does the project require the use of statistical concepts and principles?	Yes somewhat no	
Is the project complex?	Yes somewhat no	
Will the project have multiple perspectives?	Yes somewhat no	
Will the project solution(s) need justification or arguments?	Yes somewhat no	
Will the project need to be modified? If so, please specify how at the very right column for comments.	Yes no	



# VITA

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