Argumentation in an Online Mathematics Course

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DEDICATION

Dedicated in memory of Monty G. Fickel, Ph.D.

ABSTRACT

Education systems are increasingly relying on online and distance education technology as a means of delivering instruction. The issues that are faced in online education settings include how to address the distance between participants and the instructor, and the best way to deliver instruction. Although new online technologies provide the opportunity for many types of synchronous and asynchronous communication, most education settings depend primarily on asynchronous communication, due to reduced cost and increased flexibility for participants.

However, another concern in education settings is to provide a setting in which communication and discourse patterns can mirror a classroom setting and encourage critical thinking on the part of participants. This is particularly important in mathematics education, in which communication and discourse within classroom settings are included in the National Council of Teachers of Mathematics (NCTM) standards. There is a need for discussions based on reasoning and evidence to be extended to online mathematics settings.

One method which has been attempted to improve online discourse and argumentation is to request that students make use of formal argument models such as Toulmin (1958), and to compose their posts and responses to fit particular categories of argument structure. An example of such a study is Jeong and Joung (2007), in which participants discussing topics in educational technology were asked to use argument constraints for their posts, and sometimes to label their posts in terms of which argument category was used. Jeong and Joung found that the use of labels in addition to constraints reduced the number of times that participants challenged another student's post, and reduced the number of responses to challenges.

Mathematics education may differ from other fields, due to the emphasis on argumentation and proof in classroom settings. Thus the current study attempted to replicate Jeong and Joung in the field of mathematics. Participants were 25 mathematics teachers involved in professional development who discussed five mathematics topics in an online setting. They were assigned to either a Constraints Only or a Constraints with Label condition.

There were no differences between the two constraint conditions in terms of number of initial posts, challenges and challenge rebuttals. In terms of specific argument categories used, there were more Argument posts in the Constraints with Label condition, and more Critique and Explanation posts in the Constraints Only condition. Exploration of two-post sequences showed more complex patterns in the Constraints Only condition. Response quality did not differ across the two conditions.

The results only partially replicate Jeong and Joung (2007). Specifically, the small sample and small discussion groups make direct comparison difficult. However, participants in mathematics education were not reluctant to use labels in their argument structure. Future research could explore other methods of use of argument structure in online discussion.

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CHAPTER 1

Introduction

A Midwestern state has implemented a professional development series across the state with an emphasis in thinking about data analysis and probability. The largest population areas of the state are found around the two largest cities which are in the eastern third of the state. The remainder of the state consists of open spaces with low population. With such a rural setting, distance learning is essential for professional development for public school teachers.

The purpose of the Professional Development Series is to address the statewide need to build the skills and knowledge teachers require to improve instructional strategies in complex topics such as algebra, geometry, and data analysis. The ultimate goal of the professional development series is to improve student learning. The program, so far, has impacted 212 public school districts and 11 private schools statewide.

The Professional Development Series is set up with four sites throughout the state. The onsite portion is conducted four times per year, with one week sessions occurring in October, November, January and February. The onsite portion consists of workshops conducted by experts in the field of mathematics instruction. Participants engage in hands-on activities. They also discuss methods to implement in the classroom. Across the four sessions, participants discuss how those methods actually worked. Selected participants could become teacher-leaders, and were encouraged to develop online materials for learning communities (based on site participants), but this was never fully implemented by any teacher-leader.

The onsite sessions are located across the state, but still involve travel and missed work for participants. The online portion of the Professional Development Series was primarily a means for the instructors to post supplemental materials, and did not involve online delivery of the Professional Development Series. The current study was an optional supplement to the Professional Development Series that allowed participants to engage in online discussions about related material when they were not actively meeting onsite. The potential to put a larger portion of the Professional Development Series online has not been addressed. If the Professional Development Series was to be delivered as a online option, several issues would need to be considered.

The two most important problems to overcome when implementing this Professional Development Series are 1) the distance participants are from each other and the instructor, and 2) the best method of delivery for the Professional Development Series. A major goal in distance education settings has been to mitigate the impact of distance. The U.S. Department of Educational Research and Improvement defines distance education as "the application of telecommunications and electronic devices which enable students and learners to receive instruction from some distant location" (Bruder, 1989, p. 30). There are many different course learning environments that can be used for distance learning. For the Professional Development Series, the specific environment used was ANGEL. The ANGEL Learning Management Suite consists of teaching and learning tools that enable efficient and effective development, delivery and management of courses, course content and learning outcomes. (from http://www.angellearning.com/products/). ANGEL is widely used for K-12 education.

Distance education is generally understood as a form of learning where the instructor and the students are in separate locations and interact at different times. The student is removed from direct, immediate contact with the instructor. This creates a learning environment that is different from traditional face-to-face educational settings (Hassenplug & Harnish, 1998).

As distance education has evolved, so have the technologies used to support distance education. From correspondence-type classes utilizing the postal system with limited interactivity between students and the instructor to the current online connectivity allowing for synchronous and asynchronous discussions, possibly supported by real-time audio and video, the possibilities for discussion and communication between teacher and students has expanded dramatically, as well as the potential for interactions between students. Such advances make it possible to utilize communication and discussion formats in many ways to enhance education, and to provide additional opportunities for scaffolded learning aided by other students or the instructor.

This is especially important when discussing data analysis because of the importance of communication in the National Council of Teachers of Mathematics (NCTM) (2000) *Principles and Standards for School Mathematics.* These standards state that communication is a fundamental part of mathematics and mathematics education. Communication is a way of sharing ideas and illustrating understanding. Students learn to be clear and persuasive when they are challenged to communicate their thinking and reasoning about mathematics to others orally or in writing. Conversations in which mathematical ideas are explored from various perspectives help participants hone their thinking. Students who have opportunities, encouragement, and support for speaking, writing, reading, and listening in mathematics classes gather benefits that are twofold: they communicate to learn mathematics, and they learn to communicate mathematically.

To develop all five content strands (Numbers & Operations, Algebra, Geometry, Measurement, and Data Analysis & probability) of mathematical proficiency, students need to communicate their mathematical thinking, thereby engaging in a process of active construction of knowledge (Ball, 1993; Cobb, Wood, Yackel, & McNeal, 1992; Lampert, 1990b; National Council of Teachers of Mathematics [NCTM], 2000). Class discussions, it is argued, need to be based on mathematical reasoning and evidence "in order for students to develop the ability to formulate problems, to explore, conjecture, and reason logically, to evaluate whether something makes sense" (NCTM, 1991, p. 34). Instructors in the Professional Development Series modeled classroom discussions at each of the four sites across the state. The participants (teachers) were then encouraged to model this strategy with the students in their mathematics classrooms. Online discussions were also encouraged within smaller professional learning communities to ensure participation by all members of the learning community. A key element of the online discussions for the Professional Development Series and for this study included teachers engaging in argumentation and discussion about data analysis and probability.

The speculative underpinnings of learning via class discussion is the social-constructivist perspective (Vygotsky, 1978), which suggests that students actively create their knowledge through interactions with peers. Much of the research on the effectiveness of class discussion in face-to-face and online settings has focused on how both settings have context-specific advantages. Face-to-face discussions tend to have greater efficiency, immediacy of feedback, no technological issues, greater perceived interactivity and important verbal and non-verbal communication cues present. The benefits for online discussions included the asynchronous nature of discussion, the permanence of postings, and the ability to more carefully formulate responses and posts (Tiene, 2000; Wang & Woo, 2007).In short, communication is a vital part of the mathematics classroom. Students gain insights into their thinking when they present their methods for solving problems, when they justify their reasoning, or when they formulate a question about something that is puzzling them. Students increase their communication skills and move on to higher-order thinking in their communications with classmates or teachers. The need to clearly communicate about mathematical ideas can enhance mathematical thinking skills and critical thinking skills. This is true not only in face-to-face environments but also in online or distance situations.

The key issue is often meaningful communication and discussion. This communication and discussion is a key component in face-to-face classrooms but often has to be modified to fit distance education settings. Different methodologies for discussion and communication have been explored. Technology has now advanced to the point where asynchronous discussion boards and synchronous chats and video meetings can be held. Asynchronous discussions allow participants to join a discussion at a time that fits his or her busy schedule. Thus, not every participant is active in the discussion at the same time. Synchronous chats make it possible for all participants to be online and in discussion at the same time.

However, synchronous discussions have some weaknesses. They are more costly to implement. In addition, structuring synchronous communication among several students and an instructor can be logistically difficult due to scheduling concerns. For practical purposes, the Professional Development Series chose asynchronous communication due to cost and scheduling concerns. The goal is to make distant communication more convenient, more realistic, and more relevant to formal course content.

One manner in which distant communication can be made more relevant to course content is to modify discussion structure to reflect logical argument structure. Requiring learners to implement and use formal argument structure may improve the content of online discussions. The focus for this study is not on technology related to online communication, but on structuring online discussions to fit logical argument structure.

Discourse

Communication by itself does not fully support the development of higher order or critical thinking. Typically a more formal approach is required. Discourse in a mathematics classroom differs from more informal types of discussion or communication in that it is task-based, and focused on critical evaluation and application of mathematical ideas. As such, discourse can be used to enhance or create a setting for critical thinking. Students can be asked to explain statements, to provide evidence, and to refute statement. In some cases, researchers have equated discourse with formal argumentation. However there seems to be a continuum from the relatively unstructured mode of communication to more formal argumentation with discourse falling somewhere in the middle. For example: an informal communication might be as simple as “Have a good weekend.” Formal argumentation would involve following a structured argument format provided by the instructor, for example: making use of message constraints such as argument or evidence. Discourse is idea and argument-focused but not as formal as argumentation. A response in discourse could be stated as “I agree with your argument".

The word discourse is used to denote any specific act of communication, whether verbal or not, whether with others or with oneself, whether is a face-to-face conversation or asynchronous (when discussion topics online). Discourse can include verbal, nonverbal and written language. Verbal interactions between teachers and students can help to develop back and forth processes from thought to word and from word to thought (Vygotsky, 2002; Whitenack & Yackel, 2002). Discourse includes the ways in which ideas are exchanged as well as what those ideas demand. Discourse in the mathematics classroom should be founded on mathematical ways of knowing and communicating. Discourse is shaped by the tasks in which the students take on and by the nature of the learning environment. Students should be familiar with making inferences, asking questions, and suggesting both strategies and solutions to problems (Kysh, Thompson, & Vicinus, 2007).

In the NCTM *Professional Standards for Teaching Mathematics* (1991), students' involvement in the discourse-based classroom is central as they are called on to instigate lines of query and challenge the ideas presented by peers, the teacher, and textbooks. The *Professional Standards* describe the teacher's role in instigating and guiding interactions of this nature as one of eliciting and engaging children's thinking; listening carefully; monitoring classroom conversations and deciding when to step in and when to step aside. This "guide on the side" role is far from a passive one, yet it is intended to give students the space they need to direct discussion and allow students the opportunity to meaningfully explore their own mathematical ideas, articulate them, and to explore the thinking offered by others.

The NCTM *Principles and Standards for School Mathematics* (2000) encouraged student interactions in small and large group settings and stresses the benefits of discussion and argumentation of mathematical ideas among students. Suggestions for teachers' and students' roles in establishing a mathematics classroom that promotes discourse to cultivate mathematical understanding are provided by the *Principles and Standards* as well as the *Professional Standards for Teaching Mathematics* (NCTM, 1991). The teacher's role is seen to be vital for initiating and orchestrating the discourse in ways that permit students to make sense of the mathematics. Discourse is also formed by students as they use language to share ideas and mathematical evidence in making sense of the mathematics they encounter (NCTM, 1991).

Discourse and focused discussions are assumed to be an important part of mathematics education in classroom settings. These processes are assumed to improve a learner's critical thinking and mathematical thinking skills. As online education becomes more widespread, successful implementation of these processes in online settings becomes critical.

One method which has been used to support discourse is the use of structured argumentation models. Structured argumentation models are schematic descriptions, sometimes in graphical format, which make explicit the format of the argument structure, and specify the role that each statement plays within the argument. See Figure 1 for an example of how Toulmin's model might be represented in a structured argumentation model.

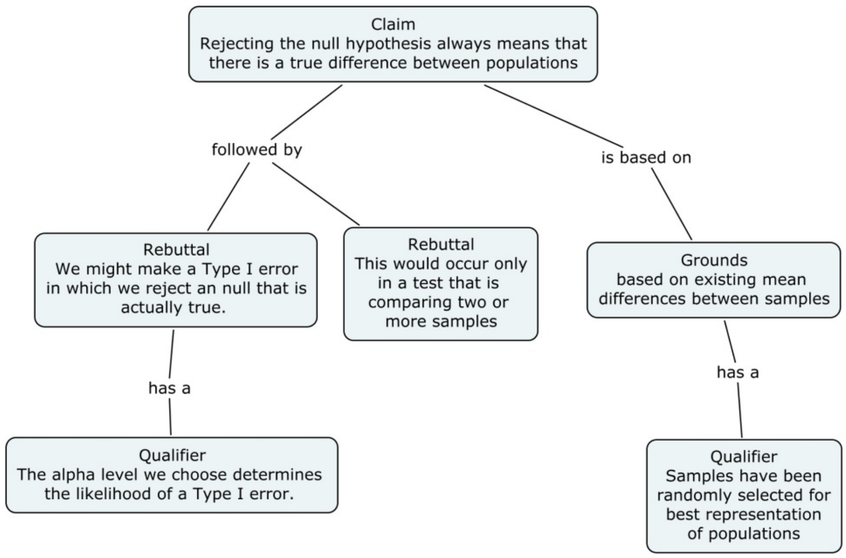


Figure 1: Demonstration of Structured Argumentation Model

Toulmin's model (1958) was the most rigorous model of argumentation and could be easily adapted into other disciplines, such as mathematics. While there are many models of argumentation, all of which attempt to describe the elements of and the process of argumentation, Toulmin's model focused on what he called practical argumentation which did not depend on logical inference but instead on justifying existing ideas or claims. Toulmin described six components of argument including claims, evidence, warrants, backing, rebuttal and qualifier.

Toulmin's model has been widely used in many domains. The benefit of using an argument model is that students are more task oriented and discussion is more focused. The use of Toulmin and similar argumentation models in online discussions may improve the quality of learning in those discussions.

The use of argument models in online discussions can be either forced or suggested. For example: a student may be required to select a label for the argument component that he or she is posting to an online discussion (forced). An alternative method would be for students to be given instruction on argument components and asked to use them (suggested).

Jeong and Joung (2007), used message categories (argument, evidence, critique, and explanation), which were based on Toulmin"s (1958) model of argumentation. Jeong and Joung's first message category (argument) identifies a message that presents one and only one argument or reason for a posting. This argument category replaced Toulmin's warrants (unspoken beliefs and values of the author, which invites the reader to examine his own beliefs and make comparisons). The second message category (evidence) identifies a reply/message that provides proof or evidence to establish the validity of an argument or challenge. This category replaced Toulmin's support (supplies evidence, opinions, and reasoning about the claim that makes it possible for the reader to accept the claim).The third message category (critique) identifies a reply/message that questions or challenges the merits, logic, or accuracy of an argument. This category replaced Toulmin's rebuttal (establishes what is wrong, invalid, or unacceptable about an argument and may also present counter arguments). The fourth message category (explanation) identifies a reply/message that provides additional support, clarification, or elaboration of an argument. This category replaced Toulmin's backing (additional evidence provided to support a warrant whenever there is a strong possibility that the audience will reject the warrant).

Jeong and Joung (2007) forced the use of argument structure through the use of labels and constraints. In a threaded discussion, students were required to classify (label) the function of their messages (e.g., argument, evidence, critique, or explanation) before messages are posted to the discussion. Jeong and Joung also placed constraints (what types of messages can be posted to a discussion) on the messages and responses. By restricting each message to serve only one function at a time, Jeong and Joung (2007) were able to examine group interaction by using message-response pairs as the unit of analysis. Their goal was to demonstrate improved argumentation through the explicit use of the argument structure (forcing students to use the constraint or the message label) in asynchronous online discussions. Jeong and Joung (2007) instructed their participants to insert the corresponding label into the message headings, and restrict the content of each message to address only one category at a time. Thus they utilized both constraints, in which participants were asked to constrain their post to only one argument category, and labels, in which participants were asked to label the message categories used.

Participants were 38 pre-service teachers who corresponded in a series of online debates on educational issues. The students were undergraduates enrolled in a course on educational technology. The topics discussed by students were related to the use of educational technology. Jeong and Joung (2007) found that students who used labels on their messages were 2 to 3 times less likely to challenge other students and 2 to 3 times less likely to respond back to challenges by others.

The domain used in Jeong and Joung's study was educational issues. It is possible that given the dependence of mathematics on formal argumentation, and the focus on discourse in mathematics education, the impact of using message constraints and labels will be different in mathematics education. Such a process makes students more aware of formal argument structure and may improve the quality of discussion responses. This may be more important or acceptable in mathematics than in other areas, due to the role of formal constraints in mathematics (such as in proofs), and the implicit constraints that become part of problem solving in mathematics. Foster, Galligan, McKrell, Mason, Melville, Piggott, Rodd, and Watson (2005) posited that every individual when doing mathematics has internal constraints. These constraints can be previous knowledge, confidence, and learning style. An example of a constraint based on previous knowledge would be if a student had no knowledge of hypothesis testing, and was asked to decide if males and females differed in verbal intelligence. An example of a constraint based on learning style would be if a student learned best when actively engaged in the material, but the instructional material is delivered in a text format that does not promote active engagement. In the current study, constraints are defined in a much narrower manner. Specifically, each constraint refers to the use of a particular argument component within the modifications Jeong and Joung (2007) made to Toulmin's model (e.g. participants are asked to select a particular argument category, (which serves as the constraint), selecting from the categories of argument, evidence, critique, and explanation). Constraints may further be combined with labels. The labeling of the argument components makes the argument structure and the particular choice that the learner makes in his or her post more explicit. Although previous research by Jeong and Joung (2007) found that the use of labels inhibited argumentation, the study of the use of argument labels and constraints in the domain of mathematics may extend this finding, or help to define situations where labels do not inhibit argumentation.

The use of constraints or combined constraints and labels based on formal argumentation models may improve argumentation by increasing students' awareness of and use of formal argument structure. Alternatively, the use of constraints and/or labels may inhibit responding – students can't just say what they think, they have to determine if it fits an argument strategy (for the constraint condition), and possibly to label their post accordingly (for the constraints plus labels condition). They may not be confident enough about their use of constraints and labels, or they might be unwilling to post something that might be viewed as “unfriendly”.

The goal of this study was to replicate the study of Jeong and Joung (2007), who examined the effects of message constraints and labels on collaborative argumentation in asynchronous online discussions. Jeong and Joung found that students who used message labels were 2 to 3 times less likely to challenge other students. Because of this, they suggested that message labels can potentially inhibit critical argumentation and possibly student learning.

In this study, the goal is to extend Jeong and Joung’s (2007) findings to mathematics education. Mathematics education may differ from other fields, as the nature of study in mathematics requires students to consistently challenge each other to justify their ideas. An argument in Mathematics, as in any other discipline, can be considered valid as long as it cannot have true premises and a false conclusion. Therefore students in mathematics might be less likely to be inhibited by the critique or argumentation of other students in their postings to online discussions, regardless of whether such critiques are labeled according to standard argument structure. (Yackel & Cobb, 1996; Wood, 1999).

The current study was a partial replication of Jeong and Jeong (2007). Participants were 25 secondary education mathematics teachers participating in an enrichment program related to statistics. They were assigned to either a Constraint Condition or a Constraint with Label Condition. In the Constraint condition, participants were asked to use argument constraints in their posts. Specifically, they were given the four argument components of argument, evidence, critique, and explanation and asked to use them in their posts. In the Constraints Plus Labels condition, the participants received the same instruction about argument components but were also asked to label their posts with one of the four argument components. Participants were also divided into three smaller discussion groups to facilitate discussion. The Constraint Conditions were distributed across the discussion groups, and the goal was to determine if the different constraint conditions resulted in discussions that required meaningful argumentation. Although previous research has examined the issue of argument constraints (e.g., Jeong and Joung, 2007), this research did not combine the constraint conditions within the same discussion groups, and did not specifically address the domain of mathematics. Thus, the current research may determine if constraints cause any changes in the quantity and quality of discussions. If the use of argument constraints improves discussions, then instructors could utilize this method to increase the level of thinking in discussion forums.

The research questions are:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?
2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations, counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?

3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?
4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?

This study is seeking to determine whether the use of constraints and labels impacts participation in argumentation in an online mathematics course. Previous research has suggested that the use of constraints and labels may inhibit discussion, but mathematics may be different in that teaching in the field is focused on discussion and argumentation. If the use of constraints and labels based on argumentation models in online discussions improves argumentation and discussion, this may provide a better way for instructors to encourage meaningful interaction in their online courses.

In Chapter One, an overview of the rationale for this study has been provided. The next chapters will show how this study addresses the two research questions. Chapter 2 provides the literature review; Chapter 3 includes the research methodology used to gather and analyze the data; Chapter 4 is the data analysis chapter; and, Chapter 5 is a discussion of the results.

CHAPTER TWO

REVIEW OF LITERATURE

This study is seeking to determine that using constraints with labels does not impact participation in argumentation in an online mathematics course. The ultimate goal of the study is to address ways to enhance communication quality in online discussions. Online classes often utilize methods for learners and instructors to communicate with each other such as discussions. An important goal is to improve the quality of communication in online classes. In this study, two different methods to enhance quality of communication are examined. In one method, students are asked to utilize specific argument structure (through the use of argument constraints). In the second method, both the posting student and all students who read the posts are made more aware of argument structure (through the requirement to label the particular type of post used in terms of argument structure. This methodology is motivated by three factors: distance education, discourse and argumentation, and methods to improve argumentation. This study adds to the mathematics education knowledge by exploring the effect of message constraints and labels on argumentation in an online mathematics course.

The National Council of Teachers of Mathematics (2000) state that communication is a crucial part of mathematics and mathematics education. Communication in the classroom can be either written or oral. Students are encouraged by their teachers to explain, clarify, and justify their thinking. In classroom settings, students communicate with each other in small group situations. They also communicate with the teacher in discussions involving the entire classroom at the end of lessons.

Communication supports student learning of new mathematical concepts as they manipulate objects, use diagrams, mathematical symbols, and write about their thinking processes. Through this communication, students are reminded that they share responsibility for their learning with the instructor. As technology became more prevalent in education, discussions were introduced in online courses.

The goal of the current chapter is to explore the implementation of communication strategies to improve discussion in an online setting. The review of the literature is organized into three parts. Part I looks at distance education, the changing roles of instructors and students in distance education, the importance of communication and collaboration in distance education, and asynchronous learning. Part II examines discourse and argumentation, applications in both the classroom and online settings, and ties to higher order thinking. Part III examines methods to improve argumentation and discourse, constraints and labels, and other methods or argumentation.

Part I: Distance Education

Until just a few years ago, distance education was conceptualized as involving a teacher interacting asynchronously with a single student. Separated by distance, the teacher and student engaged in a structured two-way exchange (Keegan, 1988a, 1993; Moore, 1973; Moore & Kearsley, 1996; Peters & Keegan, 1994) mediated by print and electronic technologies.

Definition

Definitions of distance education address the issues of separation of the instructor and student, the use of some form of communication, and the use of technology. Researchers have pointed out that one of the important aspects of the definition of distance education is the geographic separation of the teacher and the student (Simonsen, Smalatino, Albright, & Zvacek, 2000; Rumble, 1986, Keegan, 1988a). Rumble (1986) points out that this also means the student is physically separated from the institution that sponsors the instruction. Technology may be used to bridge the instructional gap (Willis, 1993). Because the instructor is removed from direct immediate physical contact with students, the learning environment and pedagogical circumstances are different from traditional face-to-face educational settings (Hassenplug & Harnish, 1998). Learners must have greater volitional control of learning (Picciano, 2001) due to this changed learning environment.

A second part of the definition of distance education is the use of some form of communication. Communication is an essential requirement of both traditional and online educational settings. Communication has evolved from the printed word being sent by post to the use of interactive telecommunications systems (Simonsen et al, 2000). Keegan (1988a) and Garrison and Shale (1987) saw the need to involve 2-way communication in the distance education classroom. Today, interactive television is in great demand in the education world. Computers and the internet allow for communication to occur more quickly for instructors and learners at different locations. Teachers and students are able to communicate through emails and online forums. The teacher and student have the advantage of time to compose their explanations and justifications to questions and problems that arise.

History

For most of the 20th century, distance education was the link between one instructor and one student. Their means of communication involved using pencil and paper, the typewriter, and the postal service. Interaction between instructor and student changed with the advances in technology. The television made it possible for one instructor to reach more than one student at a time and to interact using interactive television. Satellite distribution made it possible for the college or university to reach more students with a course. This made it possible for interaction to take place between and among students and the instructor.

The roots of distance education are at least 150 years old. In the early 19th century, a newspaper in Sweden ran an advertisement offering an opportunity to study a course through the post. This is one of the first mentions of correspondence courses being offered. Correspondence study continued to develop through the end of the 19th century through the establishment of correspondence universities and colleges. At the same time, the university extension movement promoted the correspondence method of study.

Distance education continued to look for other ways to reach students. Technology started to make an inroad into the educational institutions. A wide range of technological options became available to the distance educator. These options fall into four major categories: (a) voice tools, including telephone, audio-conferencing, and short-wave radio; (b) video tools, including slides, film, videotape, and one-way or two-way video with two-way audio; (c) data information sent and received by computers; and (d) the print-based forms from which all other delivery systems have evolved.

Distance education has been in existence for most of the twentieth century. It has made enormous strides in the presentation of the course offerings. Distance education has progressed from the correspondence course to course offerings via the internet. Most technology-based systems use one or more of the following delivery systems: one-way and two-way video conferencing, audio and teleconferencing, audio graphics conferencing, electronic mail, computer conferencing, and/or web-based delivery systems.

Distance education is often assumed to modify the roles of students and instructors, with the most common assumptions being that students are more in charge of their own learning. However, the best online teachers and classes maintain close collaboration and communication between instructors and students.

The importance of communication and collaboration has long been recognized in traditional classroom settings. The National Council of Teachers of Mathematics has specifically addressed the role of the teacher and students in discourse in classroom settings. The next section addresses the approach of the National Council of Teachers of Mathematics to the role of the teachers and students in discourse. Implementations in classroom settings will be briefly explored, followed by implementation of discourse in online settings. The focus is on the changing role of the instructor and students in online discourse.

Role of Instructors and Students

The National Council of Teachers of Mathematics in the *Professional Teaching Standards* (1991) identified six standards for teaching mathematics. One of these standards identified the role of the teacher in discourse:

- Posing questions and tasks that elicit, engage, and challenge students' thinking
- Listening carefully to students' ideas
- Asking students to clarify their ideas orally and in writing

- Deciding what to pursue in-depth from among the ideas that students raise during a discussion
- Deciding when and how to attach mathematical notation and language to students' ideas
- Deciding when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with a complexity
- Monitoring students' participation in discussions and deciding when and how to encourage each student to participate (p. 35).

As learners assume more responsibility for their own learning, it changes the role they have in their learning. The role of the instructor also changes. The faculty members' role changes from the sole provider of major information to facilitator, coach, or mentor. Broad guidelines have been provided by the National Council of Teachers of Mathematics (2000) about some of the things that teachers might do to enhance effective classroom discourse: "Effective teaching involves observing students [and] listening carefully to their ideas and explanations" (p. 19).

It is a major challenge for many instructors to incorporate discourse as part of the overall strategy of teaching and learning. How does the teacher set up practices that will enable the student to engage in mathematical discussions? Wood (2000) examined the way six classroom teachers set up norms for classroom interaction. He found that the instructor regulated the selection, organization, sequencing, pacing, and criteria of communication within the classroom. Wood's analysis showed that by varying the classroom expectations and obligations, marked differences were observed in the cognitive levels demanded of the students. This was consistent with findings reported by a number of other researchers (Dekker & Elshout-Mohr, 2004; Ding, Li, Piccolo, & Kulm, 2007; Webb, Nemer, & Ing, 2006).

Several researchers say that listening to students during discourse benefits the instructor as well as the student. Yackel, Cobb, and Wood (1998) reported on ways that a second year teacher listened to, reflected on, and learned from her students' mathematical reasoning while they were involved in discourse. The authors' analyses of the discussion revealed that the teacher's mathematical subject knowledge, and her focus on listening, observing, and questioning for understanding and explanation, greatly enhanced her perception of students' thinking.

Other researchers have also provided evidence of the critical role of the instructor in listening to students. Manouchehri and Enderson (1999), in a study undertaken within a seventh-grade mathematics classroom, found a vast incidence of student talk and interaction. A more in-depth analysis of the interactions revealed that the teacher provided responsive rather than directive support while monitoring student engagement and understanding. The teacher accomplished this through careful questioning and looking towards shifting the students' reliance from her to the support and challenge of peers. Manouchehri and Enderson clarified her primary objectives were to

- *Facilitate* the establishment of situations in which students had to share ideas and elaborate on their thinking
- *Help* students expand the *boundary* of their exploration
- *Encourage* students to make connections among different discoveries and develop a deeper understanding of the interrelationships among the patterns students identified.

- *Invite* multiple *representations* of ideas (italics are the authors) (p. 219).

As the role of the instructor has changed with the changing of the classroom environment, the role of the student has also changed from that of being a passive observer in the classroom to that of becoming an active participant. The National Council of Teachers of Mathematics (2000) addresses the role of the student to include the following points:

- Organize and consolidate their mathematical thinking through communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Analyze and evaluate the mathematical thinking and strategies of others
- Use the language of mathematics to express mathematical ideas precisely.

Implementation in classroom settings

Stein (2001) described the implementation of discussion in a mathematics classroom. The teacher poses a problem to the class, and asks each student to develop an independent solution. Once a student has publicly provided an initial response to the problem, discussion can be opened up for the entire class. This signals students that they have a responsibility to (1) listen carefully to the first students' reasoning and try to understand it and (2) formulate a critique of the answer if they do not agree with it. If any student has a different answer or approach, they should be able to critique the other student's responses, discuss their own response, and to articulate why his or her thinking is correct. The teacher's role is to clarify the sides of the debate, but students are required to support their own positions.

A good organization of classroom discourse is the inquiry- response- feedback approach IRF; Wells, 1993). In the IRF sequence, the teacher initiates the discourse (usually with a question), a student attempts to respond with an answer, and as a follow-up, the teacher provides some form of feedback to the student's response. This structure was called the "triadic dialogue" by Lemke (1985, 1990). This format is the dominant mode of conversations in the elementary classroom and accounts for approximately 70% of all the discourse that takes place between teacher and students in the secondary classroom.

In evaluating the educational significance of this form of discourse, researchers have found to be in agreement. Sinclair and Coulthard (1975) found that teachers adopt this mode of discourse by default. They offer no evaluation of its effectiveness in education. Other researchers claim that this form of discourse is functionally effective. Mercer (1992) argued that triadic dialogue is justified as an effective means of "monitoring children's knowledge and understanding", "guiding their learning", and "marking knowledge and experience which is considered educationally valuable" (pp. 218-219).

In contrast, other researchers have been much more critical of teachers' use of this form of discourse. Wood (1992) accused teachers of asking too many questions. Teachers should use a less controlling type of discourse if they really want to encourage students to ask questions of their own. Lemke (1990) urged teachers to make less use of the triadic dialogue.

Implementation in Online Settings

In both classroom and online settings, communication is the key to learning. Particularly in online settings, establishing communication early and maintaining it is often the key to continued student engagement and success. Instructors and learners both need to maintain an active status in this communication.

Online learning has often been considered to be a student-centered, collaborative process, simply because in asynchronous, online discussions, students talk more and teachers talk less. In a Sloan Consortium publication, Karen Swan (2003) states, the quality of online discussions is different from the quality of discussions in face-to-face classrooms. In particular, the role of the instructor shifts from discussion leader to discussion facilitator, and students commonly assume more responsibility. But does more student responsibility automatically mean that students are collaborating or that more learning is talking place? Here we can tum to the theory of collaborative learning in face-to-face classes for support. A recent article in the Journal for Research in Mathematics Education (Lobato, Clarke and Ellis, 2005) posits that the pervasive notion that constructivist learning is the same as holding back from "telling" students is erroneous. The authors affirm the role of the teacher within collaborative learning, and see several important functions of Instructor Discourse, including: summarizing student work, providing new information, asking about strategies, and engaging in Socratic questioning. We will see echoes of these ideas in the research on the teacher role in online learning. It is clearly important to consider the ways in which the behaviour of the instructor influences online discourse and learning.

Swan (2003) finds that evidence from studies suggests that there is a correlation between perceived student learning and interaction with instructors and with other students. It is not just teacher presence that matters, but also the quality and type of teacher interaction. A study by Yang, Newby, and Bill (2005) found that when instructors used "Socratic questioning" (probing questions that asked the students to explain more), critical thinking increased relative to students who were not asked these types of questions, and this improvement persisted even when the instructor stopped in the second half of the semester. Angeli, Valanides, and Bank (2003) observed an online discussion in which "49% of students' discourse was unsupported by advice and personal opinions." (p. 1) The authors attribute these results to a lack of quality facilitation. Palloff and Pratt (2001) contend that a good online instructor becomes a "cheerleader" to encourage the students to dig deeper into the material, and gives up some of the control of the classroom. Some instructors have a hard time making this transition, Palloff and Pratt write; openness and flexibility are key qualities that are needed. Teachers with strong classroom personalities may find that they are not comfortable online. Even when students are working in relatively autonomous groups, Kukulsa-Hulme (2004) argues that an instructor should intervene in the group in certain circumstances and should structure the group process carefully to encourage collaboration. (Merriam, Caffarella, & Baumgartner, 2007).

Garrison and Cleveland-Innes (2005) also addressed the importance of instructor interaction. They studied 75 graduate students in four classes that had different levels of instructor interaction. They found that student interaction, participation and social presence were fundamental preconditions to learning, but were not enough by themselves. They explain that" ... students are not always prepared to engage in critical discourse ...” (p. 136) However, they found that when the teacher stepped in with more of a social presence, the students adopted deeper approaches to learning. Palloff and Pratt (2001) agree that if teachers are not sufficiently present in an online course, students may become anxious that they are not doing things correctly. The authors recommend that teachers log on at least three times per week to participate in the discussions.

Students face similar challenges to instructors of online classes in terms of the need to be present in the class. Keeping in touch with the class regularly by posting to discussions is crucial. If a student does not explicitly communicate with others, he or she does not exist within the class (Misanchuk and Anderson, 2001). Feeling connected to a community of leamers is an important component of online learning. Indeed, online learning without community becomes little more than a correspondence course.

This section focused on describing National Council of Teachers of Mathematics Standards for communication and collaboration, defining communication and collaboration, and effective approaches in distance education.

Importance of Communication and Collaboration

The National Council of Teachers of Mathematics (NCTM) states that "Communication is an essential part of mathematics and mathematics education" (2000, p. 60). In fact, communication is one of the five process standards emphasized by NCTM. The communication standard highlights the importance of young children communicating their mathematical thinking coherently to peers and teachers. The *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) posits that “talking mathematically helps the students to clarify, refine, and consolidate their thinking” (p. 6) and thus furthers learning and improves the quality of the ensuing knowledge.

Communication can be defined as “the imparting or exchange of information, ideas, or feelings” (Collins Dictionary of the English Language, 1986). Encyclopedia Britannica (1998) defines communication as “the exchange of meanings between individuals through a common system of symbols". Communication can include speaking, reading, writing, and listening. All of these aspects of communication are included in a collaborative learning community. Collaboration strategies have successfully been used in the traditional face-to-face classroom: rotate small-groups stations, pyramiding, cocktail party, and jigsaw. The distinction in collaboration is that often some product is required.

Communication is the biggest challenge in online collaboration. Thompson and Ku (2006) noted participants in an online course found it difficult to work collaboratively without face-to-face meetings. Time and distance prevented such sessions, so they had to communicate with each other via e-mail and group discussion board. The asynchronous nature of the online communication proved to be problematic in terms of meeting time constraints for editing group projects, and one of the groups actually scheduled phone calls to get more timely feedback from group members. (Thompson & Ku, 2006).

Another challenge in online collaboration is conflicts between group members. Some members want to address projects as soon as they are assigned while others seem to work at the last minute before the project was due. Thompson and Ku (2006) stated that some groups worked on the "majority rules" idea to solve conflicts. This seemed to cause more conflicts within the group. Comments which build community and strong commitment to group projects proved to be effective in solving conflicts among some group members.

Spector (2005) focused on e-collaboration, alternative methods and different technologies used by students to work with each other, tutors, and teachers to achieve a specific learning outcome. Common e-collaboration techniques include:

- minimal collaboration – collaboration with a tutor or teacher via asynchronous means such as e-mail
- modest collaboration – asynchronous threaded discussions with topics posted; this form involves more focus and structure than is characteristic in normal e-mail
- modestly elaborate collaboration – synchronous forum groups with semi-structured small group assignments and goals; this requires coordination of time schedules in addition to more structure and focus than in typical e-mail
- elaborated collaboration – asynchronous and synchronous audio- and video-based methods; this involves most far-reaching use of technology and synchronization of plans and activities.

Increasing students' overall feeling of success and academic motivation is one of the most important benefits of collaboration. Collaboration among students involves self-consciousness about purposes, mutual interdependence, capacity to benefit from differences, and the ability to resolve differences (Gamson, 1997).

Collaboration and discussions conducted in most online courses use the asynchronous learning setting. This setting makes it possible for the participants to enter discussion formats as their busy schedules dictate. The first format to be used for discussions was e-mail, usually between two students or a student and the teacher. This was followed by the use of discussion boards and extended in chat rooms. Although chat rooms allow for simultaneous synchronous learning, it is less often used than asynchronous threaded discussions.

Discussion board is an asynchronous tool which provides an opportunity for each individual to post a claim as well as to respond to the postings of others. The postings in a discussion board are threaded, which means that several topics can be discussed simultaneously. When a student makes their initial post, others can reply by having their posting appear indented underneath the initial posting.

The discussion board promotes an environment where each person's contributions are respected. This may be different than the classroom setting, where some individual may not speak up for fear of having an incomplete or incorrect answer. The goal of the threaded discussion is to advance the collective knowledge and thus support the growth of individual knowledge. Churchill and Bly (2000) developed guidelines for the design of online environments. The online environment should have a feeling of permanence and the focus should make it easy to create and move among groups. The design should allow integration of artifacts and conversations, should be easy to use, and should allow for different technology capabilities.

Vess (2005) looked at the asynchronous discussion patterns in the role playing activities of online and hybrid history courses. He found that the students of the completely online portion of the course formed learning communities outside the assigned discussion area. In this learning community, they asked questions of each other rather than the instructor. The online debates were found to be better than the in-class debates because the students had the chance to research something and state their opinion without interruption. This benefit outweighed the frustration of having to wait for a response.

In Part I, the author has discussed distance education (giving definition, history, and opportunities), the importance of communication and discourse in both online and classroom settings (using the National Council of Teachers of Mathematics Standards as a starting point), and the important role of communication and collaboration primarily in online settings. It is important to note that for online education to be most effective, both students and instructors must maintain an active role in the class. Students in particular have a greater responsibility to directly engage in discussion and learning (due to specific requirements for interaction), which might not be present in a classroom setting. Part II will address more formal approaches to communication, and how these might be applied in online settings. Specifically the role of formal discourse and argumentation in classroom and online settings will be addressed.

Part II: Discourse and Argumentation

Discourse and argumentation have been around since the time of Aristotle. Discourse consists of at least two premises. Communication in the classroom evolved from recitation in the first part of the last century to small group discussion and then to whole-class discussion. This section will start with the definitions of discourse, interaction, collaboration, and argumentation. The applications of discourse and argumentation in the classroom and online settings will then be discussed along with ties to higher-order thinking.

Definitions

Discourse is defined by Random House Dictionary as “formal discussion of a subject in speech, or writing” or “communication of thought by words”. Discourse first started as oral communication and then changed to the written word. This paper will address both the oral and written aspects of discourse. Collaboration means to work together, especially in a joint intellectual effort. In online threaded discussions, collaboration is a very essential part as the participants are separated by great distances. Webster defines argumentation as “the act of forming reasons, making inductions, drawing conclusions, and applying them to the case in discussion”. A course of action is adopted or a conclusion is reached through the interaction of group members and their study of different aspects of the topic.

Interaction is defined by the American Heritage Dictionary of the English Language as “the act or process of interacting” or “to act upon another”. The prefix inter, from the Latin means between, thus interaction is the process of communication between people. Interaction is implied in each of the above. Distinction between discourse, collaboration, argumentation, and interaction are often not well specified and in some cases the terms are used interchangeably. In mathematics education, discourse is often more formal than in other areas. In mathematics education the concept of mathematical proof has historically depended upon the fairly strict structure of argument. Understanding the difference between facts and claims, and supporting claims is an essential part of the mathematical process.

Mathematical discourse is about figuring out what is true, once the community members agree on their definitions and assumptions. These definitions and assumptions are not given; but are mediated in the process of determining what is true. Students learn about how the truth of a mathematical assertion gets established in mathematical discourse as they meander between their own observations and conclusions disclosing and testing their own definitions and assumptions as they go along.

Discourse, interaction, and collaboration have been used extensively in the mathematics classroom. Researchers such as Marilyn Burns, Deborah Ball (1993), Anna Sfard (2002, 2007) and others have written about working and discussing mathematics with school children. Marilyn Burns has a series of video tapes in which she demonstrates to pre-service elementary teachers how to encourage discourse in the elementary mathematics classroom (from MathSolutions.com). Students are encouraged to talk about their mathematical thinking. If another student disagrees, they try to influence the class that their particular strategy is correct. The teacher's role is that of giving oral prompts to produce higher levels of reasoning in students' discourse. The teacher also provides support and elaborates on how each piece of support relates to a students' claim.

As technology entered the world of education, we see discourse changing from the traditional face-to-face classroom. When two-way video was introduced, the student and teacher are separated by a physical space. At first instructors found that interacting with the distant component of the course was not as easy as interacting with the face-to-face component. Instructors found that some of the same strategies used in the classroom would work over a two-way video feed. Problems were introduced in the class and students were left with the task of finding a strategy for solution. Upon completion of the group work, the students were to present their strategies and then discuss them as a class.

With the introduction of online courses, a new method of discussion needed to be found for courses. Discourse was already being used as a means of communication in the face-to-face classroom. This means of communicating was tried in the online course. Several changes were made to insure student interaction. Nussbaum (2002) noted that teachers need to scaffold discourse, which later became known as argumentation. Instructors informed students that in formulating argumentation, they needed to be explicit about how their reasons and evidence relate to their claim.

Steinhuehler, Derry, Levin, and Kim (2000) posited that the shift towards argument contains more statements of justification. Students demonstrated an increasing awareness of the consistency and quality of their thinking. The individual's post engaged in discussion reported greater personal contributions to the activity.

Discourse and argumentation have several benefits among which are the involvement of more students, more clarification of postings, questions are asked for additional information, higher levels of reasoning, conversational interaction, and students can initiate sequences of discourse. Along this same line, Ferdig and Roehler (2004) suggested five areas where through the use of discussion forums in Web-based learning environments a positive impact can be made on teaching and learning.

> The first of these areas is *interactivity*, where students learn to rely on each other for support. Student participation can be increased by giving everyone a voice and at the same time can provide students with an appreciation for diverse viewpoints and perspectives.
>
> *Active learning* can be promoted through student ownership. The use of discussion forums helps students make connections, allows them to reflect, and evaluate. Through the use of discussion forums, students share resources while they problem solve.
>
> Discussion forums are shown to promote stronger *teacher/student relationships*. This relationship is strengthened through changing the way interaction occurs. Students and teachers feel connected by receiving feedback that is well thought out. The discussion forum allows the instructor to model appropriate skills and provides the students to have a say in the instruction.
>
> An *increase in higher order thinking skills* has been observed as students have become better at critiquing, questioning, and scrutinizing. Discussion

> forums provide a way for students to reflect and integrate new information. Through the use of the discussion forum, students have become better at making connections, extending content and critical thinking.
>
> Discussion forums allow students and teachers to demonstrate *flexibility* in their thinking. In online discussions, students are given time to think out their responses. This allows the response to be more in-depth and structured (p 120-121).

Teachers in Ferdig and Roehler's (2004) study found that using discussion forums helped them to teach constructively. They found the use of Vygotsky's theory (1978), the zone of proximal development (ZPD) to be very useful. The goal of the teacher is to use content at the high end of students ZPD, where learning takes place with adult guidance or collaboration with more knowledgeable or more capable others.

Applications in classroom and online settings

Argumentation and discourse are used in both the classroom and online settings. The major difference is that the students in online settings are not able to meet face-to-face for any portion of the course. Students need to be aware of communication issues when working online in groups. Students may use e-mail, chat rooms, and the discussion format in the course for their communications.

In the online course, certain strategies such as scaffolding are taken over by the members of the group rather than the instructor. Instead of verbal prompts given by the instructor in the classroom, written prompts are sent by members of the group to produce higher levels of reasoning. Other strategies taken over by the students are providing support and elaborating on how each piece of support relates to the claim. Students also explain and defend their own principles and take an interest in responding to and critiquing ideas of others in the discussion (Clarke & Sampson, 2007).

The role of the instructor in online setting is to serve as a facilitator (during activity time in the classroom), provide opportunities for students to connect new understanding to prior knowledge, provide opportunities for self-expression by the student informally, ask a variety of questions, encourage use of appropriate mathematical terms, and connect administrative tasks or classroom routines to mathematics (Cooke & Buchholz, 2005). Other roles of the instructor include: initiating and guiding development of discourse, develop symbolic records, choose problems that promote discussion, follow students' arguments and collect evidence to support or challenge their arguments, and support students as they attempt to support or challenge other's arguments.

In the discussion portion of the course, the instructor should act as a participant as well as a facilitator. The instructor should help learners identify the important threads of conversations. This is especially important for students who are experiencing online discussions for the first time. The instructor should be responsive. Feedback is important and needs to be specific, personal, and within 24 hours of the posting.

Web-based environments utilize online discussions, which are usually threaded asynchronous or synchronous chats. Students seem to prefer asynchronous discussions as they have time to reflect and draft carful responses to others' postings. The format should promote an environment where each person's input is respected. The goal of the discussion is to advance the combined knowledge of the group and in that way to support the growth of individual knowledge.

In a threaded discussion, students may respond to any contribution in the discussion at any time. The response comments are placed by the software underneath the comment to which they are replying and indented. The structural outline of a hypothetical fragment from a typical discussion generated from one claim is outlined in Figure 2 to help explain the coding of an episode.

1. Initial claim from Group A
    1.1 Group C rebuttal to 1
        1.1.1 Group E supports 1.1 with data
            1.1.1.1 Group A supports 1.1 and 1.1.1 and changes position
            1.1.1.2 Group B agrees and says that they understand
        1.1.2 Group B queries for a clarification of 1.1
    1.2 Group B agrees with 1
    1.3 Group D agrees with 1 and adds supporting data
        1.3.1 Group C rebuts the data in 1.3

Figure 2. Structural outline of a hypothetical fragment from a typical discussion from one initial claim to help explain the coding of an "episode" as well as to explain the structure of asynchronous online discussions for readers not familiar with these forums

Although the example in Figure 2 shows students understanding argument structure, the structure of threaded discussions is often relatively informal, and does not always match proper argument structure. Supporting students in discussions is essential to making discussions more relevant.

Developing such a community of inquiry is not completed without problems. Students need to understand their responsibility as active contributors to the instruction. They cannot assume that either the teacher or other students will carry the load in the on-line discussion. A community of inquiry and asynchronous learning favors a more mature student, one who is self directed and willing to take on responsibility for his/her own learning.

An area that may become troublesome in an online discussion is misinformation. Students need to have the knowledge base and experience to examine the discussion for misinformation. Sproull and Kiesler (1991) caution about discussions that continue based on misinformation. An instructor, in asynchronous learning, cannot correct or clarify a comment immediately. In asynchronous learning, the amount of student participation can increase and the number of comments can easily lead to what Mackay (1989) described as information overload. Comments in online discussions tend to be longer than face-to-face situations.

The loss of visual clues during a discussion is another feature of interaction that can be problematic in asynchronous learning. Body language is important in a face-to-face discussion. A student's smile can be interpreted by others as understanding the topic; a frown or puzzled look can be interpreted as a lack of understanding, a lack of patience, or nervousness. The student is also unable to see the expressions or hand gestures of the teacher that would be provided during a face-to-face situation. In asynchronous learning, the student needs to depend upon clues that may be identifiable reading the wording closely in a posting.

The field of research on threaded discussions has benefitted from the development of a number of rubrics. Edelstein and Edwards (2002) developed a rubric which established five categories for communications: promptness and initiative (timely and consistent engagement), delivery of post, relevance of post (to the current discussion), expression within the post (how well ideas are presented), and contribution to the learning community. This rubric also helps faculty evaluate their own involvement and contributions to the discussion.

In summary, threaded discussions can be used to develop formal argument structures. To the extent that this occurs, learners may develop and use higher order thinking skills, especially the skill of critical thinking.

Ties to Higher-order Thinking

In a study of critical thinking in computer-mediated communications, Garrison, Anderson, and Archer (2001) proposed a four-stage process: (1) posing the problem (triggering), (2) search for information (exploration), (3) construction of possible solution (integration), and (4) critical assessment of solution (resolution). The authors hypothesized that the low numbers for construction and critical assessment of the solution may be due to the need for more time to reflect on the problem. The authors also noted that individuals would hesitate to offer insufficient solutions in a classroom setting in order to avoid rebuff.

Online discussions at a distance can involve collaboration in many of these stages, and students can work together to reach a deeper understanding of mathematical concepts. In online settings, insufficient solutions may be less personal, risky, and may be accepted as part of the solution process. Online discussions can provide a way for students to collaborate in these processes, to encourage proper argument structure, and to remind students about the goal of their posts.

Part III: Methods to improve argumentation

The use of formal argumentation models may encourage the development of higher order thinking skills. Several models of formal argumentation have been proposed (e.g., Toulmin, 1958; Andrews, 2005; Mitchell & Riddle, 2000). If formal argumentation is required in an educational setting such as mathematics, students may require some assistance and reminders about the formal argumentation process. In this section, popular argumentation models will first be reviewed. Then a specific method to improve the argumentation process will be discussed, specifically asking students to more specifically use formal argument structure.

Models

Toulmin's model is to provide a test for the soundness of arguments. The key axes of his model (Figure 3) are the relationship between the claim and the grounds and the relationship between the warrant and the backing. Negotiating between the claims and the grounds is the possibility of a qualifier. A rebuttal might be included to challenge the relationship between the grounds and the claims, either helping to strengthen the relationship or provoking it to change.

A claim is the main point of the argument that organizes the argument and everything related to the argument. The grounds are the supporting evidence that upholds the claim. The arguer supplies evidence, reasoning, examples, and factual information about the claim. The warrant is the chain of reasoning that connects the grounds to the claims. A warrant originates with the arguer, but may also exist in the minds of the audience. Unspoken beliefs and values of the author are revealed in the warrant and the reader is invited to examine these beliefs.

The backing provides additional justification for the warrant. The qualifier states how sure the arguer is about his or her claim. Here we find the specifications or limits to the claim. The rebuttal establishes what is wrong, invalid, or unacceptable about an argument. A rebuttal may present counter claims or new arguments. According to Inglis, Mejia-Ramos, and Simpson (2007), the argument would be read, 'providing grounds and warrant (given backing), we can qualify and conclude the claim, unless there is a rebuttal'.

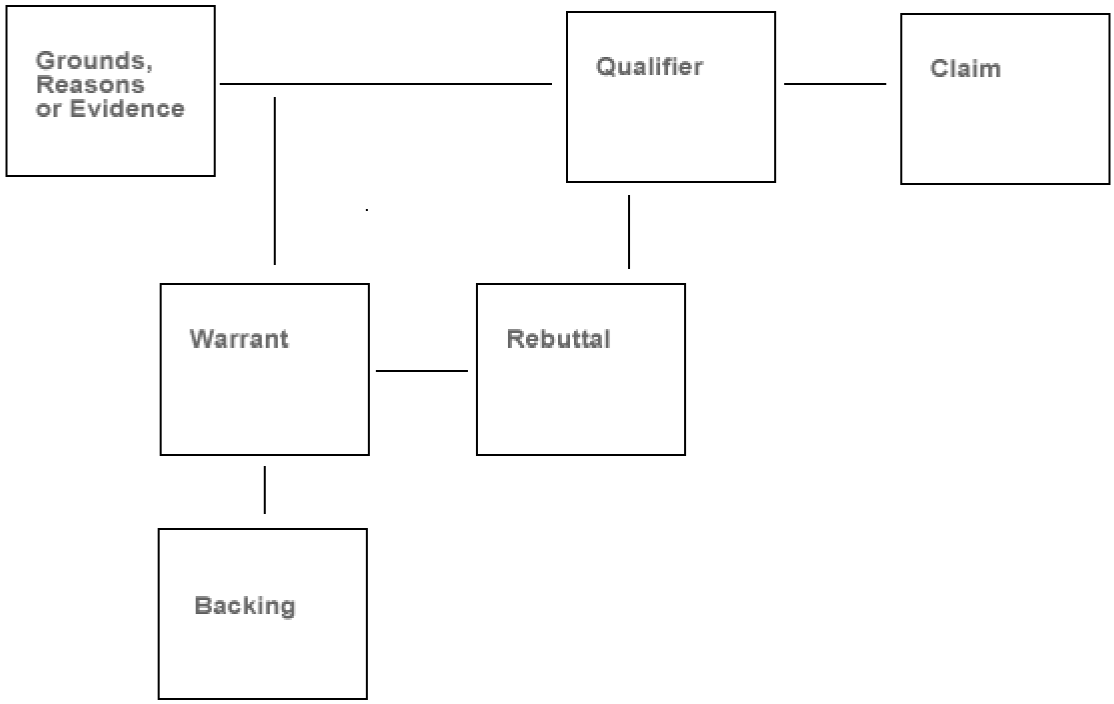


Figure 3: Toulmin's 1958 model of argumentation.

Toulmin (1984) reconstructed the model to make its meaning clearer. The driving force behind this model is the basis of the claim. This model is used more in testing the strength of existing arguments rather than generating new arguments. In the context of education, this model might be best used to calculate the soundness of a draft argument before proposing the final version for debate.

Mitchell and Riddle (2000) improved the Toulmin model of argumentation. Their model uses everyday language and is based on the three words: since, then, because. The Mitchell-Riddle model can serve as a generative tool for the planning and composing of arguments. Students will begin with a since statement, support this with a then and because is the justification of the initial statement. Figure 4 shows the Mitchell-Riddle model of argumentation.

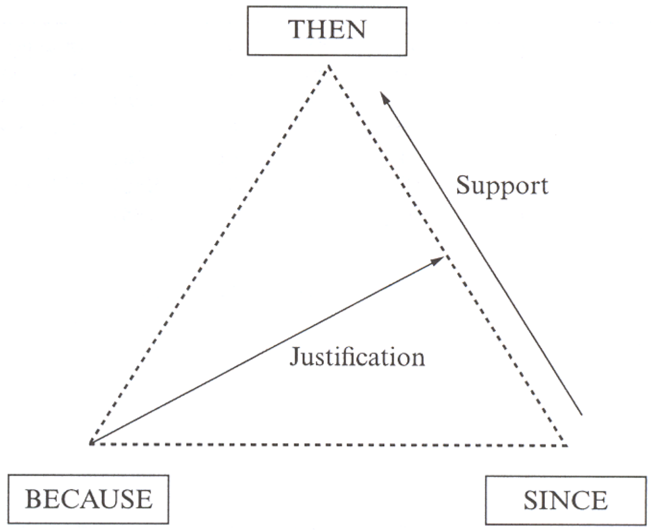


Figure 4: Mitchell-Riddle model of argumentation

Andrews and Kaufer and Geisler developed models that are concerned with the composition of argument. Andrews based his model on Vygotsky's theory of concept development (Vygotsky, 1986), which moves from heaps through complexes to concepts. Vygotsky's view is that thoughts develop from uncollected heaps of ideas that begin to cluster when a consolidating idea brings them together (Figure 4).

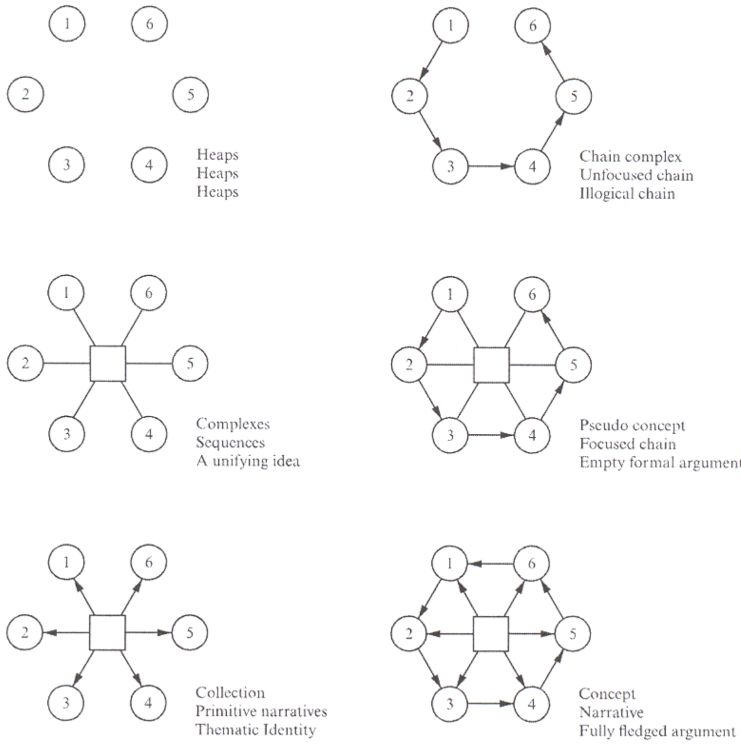


Figure 5: Andrews model of argumentation

Andrews (2005) tells us that argumentation can begin with *heaps* of ideas. These ideas then begin to unite when a *unifying idea* is introduced to hold them together. This cluster then achieves *thematic unity* when the central idea is linked to the original ideas. At the same time, an *illogical chain* might be made to connect the various ideas together. The thematic unity and illogical chain combine to form an *empty formal argument*, which does not contain the completeness of the fully fledged argument. In the final stage, the *fully fledged argument*; all the ideas are connected to each other to complete the argument.

The Kaufer and Geisler (1991) model epitomizes much of what happens in the construction of academic writing arguments. Kaufer and Geisler suggest that in formulating the eloquent space for a new line of argument, writers often position themselves in opposition to an existing assumption or argument. This faulty path seems to have the writer straying from his or her main path. However, a way is found back to the main path which is makes the direction of the main path clearer. A number of paths could have been taken to arrive at the final argument, but a particular path was taken. This path is strengthened by the other points addressed along the way.

Constraints and labels

Regardless of which specific argumentation model is selected, students may need some support in terms of using the model. One way to provide this support is through asking students to constrain their posts to fit the elements of argument structure.

In a general sense, constraints are defined as limitations or restrictions (dictionary.com). Constraints help us focus on the different areas of the problem and aid us in its solution. The guidance we are needed in solving a problem is provided by the constraints, which also set the boundaries to our understanding. Within the context of applying constraints to online argumentation, participants are asked to construct their posts so that they fit one or more aspects of specific argument structure.

Within mathematics, constraints are required to solve problems and understand relationships. Constraints are so implicit to the mathematics we learn that most of the time they are instinctive. Students are constrained by the tasks given to them by their instructors and by the resources with which they are provided or not provided. Foster, Galligan, McKrell, Mason, Melville, Piggott, Rodd, and Watson (2005) posited that every individual when doing mathematics has internal constraints. These constraints can be previous knowledge, confidence, and learning style. The mathematical experience can be enriched or hampered by any or all of these constraints.

Label is defined as to classify or categorize. In asynchronous threaded discussions, labels are used to tell what type of argument a person is addressing in their posting or reply. The label may also include whether the posting is in favor of or opposed to a given subject. Explicitly labeling an online post increases awareness of the role that post plays in the ongoing discussion (both for the person who posts, and for anyone reading the post)..

If students can be persuaded to use constraints and labels that match the elements of argument structure, they may provide more thoughtful and meaningful posts in online discussions. They may be more likely to engage in the higher order thinking that is involved in critically evaluating another person's online discussion post. Students who use constraints and labels matching elements of argument structure will be required to explicitly consider the role of their post in the online discussion.

Jeong and Joung (2007) examined the effects of constraints and label on collaborative argumentation in an asynchronous online discussion. Jeong and Joung examined the effects of constraints and label on collaborative argumentation in an asynchronous online discussion. Participants were asked to use message categories in their posts that Jeong and Joung derived from Toulimin's (1958) model of argumentation. Toulmin's model was the most rigorous model of argumentation and could be easily adapted into other disciplines, such as mathematics. The message categories used were argument, evidence, critique, and explanation. In argumentation, the argument is in support of the proposition; evidence uses specific examples, such as research studies, personal observations and experiences, or proof; critique challenges the given arguments, evidence, or other responses; and the explanation clarifies or elaborates. Jeong and Joung (2007) instructed their participants to insert the corresponding label into the message headings, and to restrict the content of each message to address only one category at a time. Jeong and Joung found that in the field of educational technology, pre-service teachers who used labels on their messages were 2 to 3 times less likely to challenge other students than students who did not label their messages. In addition, they were 2 to 3 times less likely to respond back to challenges by others.

In this study, the goal is to extend Jeong and Joung's (2007) findings to mathematics education. Mathematics education may differ from other fields, as the nature of study in mathematics requires students to consistently challenge each other to justify their ideas. An argument in Mathematics, as in any other discipline, can be considered valid as long as it cannot have true premises and a false conclusion. Therefore students in mathematics might be less likely to be inhibited by the critique or argumentation of other students in their postings to online discussions, regardless of whether such critiques are labeled according to standard argument structure. (Yackel & Cobb, 1996; Wood, 1999).

The research study was a partial replication of Jeong and Joung (2007). Participants were 25 secondary education mathematics teachers participating in an enrichment program related to statistics. They were assigned to either a Constraints Only or a Constraint with Labels Condition. In the Constraints Only condition, participants were asked to use argument constraints in their posts, based on the categories used by Jeong and Joung. In the Constraints with Labels condition, the participants were also asked to label their posts with one of the four argument components. Participants were also divided into three smaller discussion groups to facilitate discussion. The Constraint Conditions were distributed across the discussion groups, and the goal was to determine if the different constraint conditions resulted in discussions that involved meaningful argumentation.

The research questions are:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?
2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations, counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?
3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?
4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?

Previous research has suggested that the use of constraints and labels may inhibit discussion, but mathematics may be different in that teaching in the field is focused on discussion and argumentation. If the use of constraints and labels based on argumentation models in online discussions improves argumentation and discussion, this may provide a better way for instructors to encourage meaningful interaction in their online courses.

Thus, the current research may determine if constraints cause any changes in the quantity and quality of discussions. If the use of argument constraints improves discussions, then instructors could utilize this method to increase the level of thinking in discussion forums.

Summary

Distance education relies on students and instructors taking an active role in the communication process. The National Council of Teachers of Mathematics defines critical roles of instructors and students in discourse, primarily for classroom settings. Translation to the online setting is not necessarily direct. Some advantages to online learning are less risk for students to present partial solutions, specific types of dialog/discourse can be introduced by the instructor, the instructor can teach and implement argumentation models to potentially improve the quality of the discussion, constraints and labels can be used to encourage more thoughtful discussions. The goal of the study is to examine the effects of message constraints and labels on collaborative argumentation in asynchronous online discussions.

CHAPTER THREE

Methodology

The Study

This study replicated the study of Jeong and Joung (2007), who examined the effects of message constraints and labels on collaborative argumentation in asynchronous online discussions. Participants were pre-service teachers discussing educational technology. Jeong and Joung found that students who used message labels were 2 to 3 times less likely to challenge other students. They suggested that message labels can potentially inhibit critical argumentation and possibly student learning. The goal of this study is to extend the effects of message constraints based on argument structure (what types of messages can be posted to a discussion) and message labels (classify messages by type as they are posted) to mathematics education. Mathematics education may differ from other fields, as the nature of study in mathematics requires students to consistently challenge each other to justify their ideas. Therefore students in mathematics might be less likely to be inhibited by the critique or argumentation of other students in their postings to online discussions, regardless of whether such critiques are labeled according to standard argument structure (Yackel & Cobb, 1996; Wood, 1999).In fact, due to the nature of mathematics, such argumentation may actually enhance engagement in and excitement about discussions.

The questions for this study are as follows:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as

compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?

2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations, counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?
3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?
4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?

In the Professional Development Series, participants were asked to respond to posted discussion questions, and encouraged to explain, provide evidence, or challenge the posts of other members of the discussion. The instructors would join the discussion to ask questions of clarification or to support a posting.

Although the primary method of analysis in the current study is quantitative, based on the frequency of responses, other analyses will focus on qualitative aspects of the messages, and on sequence analysis of the messages and responses. The analysis of discussion messages in online discussions requires several approaches. At a base level, simple frequencies of particular types of responses in different experimental conditions can be recorded. However, a more complete analysis requires a combination of quantitative and qualitative methods.

Of special interest to the current study is the qualitative case study, described by Merriam (1988) as a type of research having its own characteristics and uses. It provides a methodology for examining familiar issues. Interpreting familiar, daily occurrences makes "…the familiar strange and interesting again – everyday life is so familiar that is may be invisible" (p. 165). Creswell (1994) defined the case study situation "in which the researcher explores a single entity or phenomenon 'the case,' bounded by time and activity (a program, event, process, institution, or social group) and collects detailed information by using a variety of data collection procedures" (p. 12).

This study had multi-case aspects. Each discussion group constituted a case bounded by time. Each discussion group constituted a separate case. Additionally, each discussion group was compared to the other groups. Collectively, they were the study participants. The study participants were members of a professional development group in a Midwestern state who studied data analysis and probability in a series of five workshops. The participants volunteered to take part in the study discussions, which were separate from the professional development series.

The role of the researcher in qualitative research must be carefully addressed, as there is a potential for researcher bias to enter into the analysis. Qualitative research is dynamic and ever changing as data are collected and interpreted. As a qualitative researcher, I was the research instrument exploring message constraints within discussion upon mathematical topics in data analysis and statistics and determined the discussion question for the participants. My role was to describe the frequency and determine if message labels enhance discussion.

The current study utilized a mixture of quantitative and qualitative methods of analysis, including quantitative analyses based on frequency counts in different conditions, as well as event sequence analysis and coding of responses. This chapter will focus on the method and dependent variables. Results will be discussed in Chapter IV.

Method

Participants

Twenty five participants (6 male, 19 female) were recruited from a Mathematics Professional Development Series in a Midwestern state. Participants were a subset of the 161 middle and secondary mathematics teachers selected to be part of the Mathematics Professional Development Series. This subset of individuals volunteered to take place in the study. Participants in the Mathematics Professional Development Series were approached by the author to participate in this study during the second workshop in October. They were given a letter describing the research and a consent statement to sign and return to the author. All procedures were carried out in accordance with Institutional Review Board guidelines.

Context

The Mathematics Professional Development Series is a statewide initiative to give support to schools that have received failing grades through NCLB (No Child Left Behind). This was the third year of the development series and focused on data analysis and probability. The participants were middle and secondary mathematics teachers who applied to participate in the Professional Development Series, and who were approved by their Superintendents. The number of seats for the Professional Development Series was capped at 200 for the research period. Participants were middle or high school mathematics teachers who currently teach data analysis and probability.

The Professional Development Series was intended to provide the middle school and high school mathematics teachers with several activities that could be used within the classroom. As the teachers used these activities, they wrote a summary and provided some student work. These were discussed in the next workshop, where student interactions during the activity were discussed and revisions to the activity were noted. Thus, the focus for the Professional Development Series was on how the information and activities could be used in the middle school and high school mathematics classroom.

For the purpose of the study, an additional five optional discussions were added to the Professional Development Series. These discussions explored similar themes to those addressed in the main component of the Professional Development Series, but the focus was on conceptual understanding of topics related to probability and data analysis, rather than on classroom implementation. The five online discussions took place over a ten week period from December to February, with a new one introduced at two-week intervals. Twenty five out of the 161 participants in the Professional Development Series participated in at least one of the discussions. Since participation in this research study was an optional part added on to the Professional Development Series, this rate of response is not surprising.

Consent and debriefing

Appendix A contains the consent form requiring the signature of each participant. After approval by the Institutional Review Board, participants of the Mathematics Professional Development Series were invited to join the research study. The invitation consisted of a consent form that explained the study and the procedures. The consent form also included a description of how the groups would be divided into subgroups with

Constraints and Constraints with Labels, and information about potential risks and benefits of participation.

After the study was completed, a debriefing was disseminated to the 25 study participants in the form of an executive summary. The Mathematics Professional Development Series will also receive a copy of the executive summary. The Development Series interest in the study lies with the formation of discussion groups and how to conduct an online discussion using argumentation.

Design and procedure

Although the primary comparison is the Constraints versus the Constraints with Labels condition, participants were randomly assigned to three separate discussion groups, to increase individual responsibility, and to enhance group performance. It was assumed that smaller groups would increase participants' level of responsibility and participation in the discussion. This assignment was not related to the research questions, and was designed to promote active discussion. Each discussion group had 8 or 9 members. Group A consisted of 2 males and 6 females. Group B consisted of 2 males and 7 females. Group C consisted of 2 males and 6 females. Within each discussion group, half of the participants were assigned to the Constraints Only condition, and half were assigned to the Constraints plus Labels condition. Within each condition, half of the participants were assigned to present arguments that supported the initial position in the debate (posted in the discussion), and half of the participants were assigned to oppose the initial position. The conditions are depicted in Table 1. However, some participants who signed up did not actually participate. Thus in some conditions, the number of participants initially assigned in each category did not match the number of actual participants. These cases are indicated in bold type in Table 1. Discussion Group B was the most impacted. However, a comparison of the Discussion Groups indicated few differences.

	Constraints Only		Constraints with Labels	
	Support	Oppose	Support	Oppose
Group A (n = 8)	Assigned 2 Participated 2	Assigned 2 Participated 2	**Assigned 2** **Participated 0**	**Assigned 2** **Participated 1**
Group B (n = 9)	**Assigned 3** **Participated 0**	**Assigned 2** **Participated 0**	**Assigned 2** **Participated 1**	**Assigned 2** **Participated 2**
Group C (n = 8)	**Assigned 3** **Participated 1**	**Assigned 1** **Participated 0**	Assigned 1 Participated 1	Assigned 3 Participated 3

Table 1: Number of Participants assigned and participating in each category with the conditions.

The constraints used were based on the message categories developed by Jeong and Joung (2007). Jeong and Joung's (2007) message categories were based on Toulmin's (1958) model of argumentation. The message categories included arguments, evidence, critique, and explanation (See Fig. 3)

ARGUMENT	Argument in support/or opposition of the proposition. For example: Computers can substitute the role of the instructor when kids use computer-based tutorials”. The subject heading for this argument might be something like “ARGs computers as tutors.”
EVIDENCE	Evidence, specific examples, research studies, personal observations & experiences, or proofs in support/or opposition. For example “I found an article that shows that…”or “In one course, I used a computer tutorial and I found that…”. The subject heading for these messages might be called “EVIDs: study finds tutorials to be effective”.
CRITIQUE	Challenge or critique given arguments, evidence or any other responses from the opposing team. For example, “The personal experiences you’ve had with computer-based tutorials cannot be generalized to other students because…” or “The study you cited was flawed because…”
EXPLANATION	Explanation, elaborations or clarifications in support/or opposition. For example “Computer-based tutorials perform the specific role of assessing students understanding just as an instructor can administer pop quizzes in a classroom”.

Figure 6. Message categories used to scaffold and label messages during on-line argumentation. Students were also required to insert tags (“o” = opposing, “s” = supporting) at the end of each label to identify postings from the opposing versus the supporting team. For example: ARGs for an argument from the supporting team and CRITo for a critical response from the opposing team.

In the Constraints Only Condition, participants were instructed to (a) post specific types of messages from a prescribed set of message categories such as arguments, evidence, critique, and explanation (See Figure 6), and (b) restrict the content of each message so that each message addressed only one category at a time. Participants in the Constraints with Labels Condition were instructed to (a) post specific types of messages using the same prescribed set of message categories used in the Constraints Only Condition, (b) restrict the content of each message so that each message addresses only one category at a time, and (c) label each message with a prescribed label assigned to each message category. Participants were instructed to insert the labels into the subject headings of each message.

Within each of the three discussion groups, participants were required to post a minimum of four messages per debate in a threaded discussion forum on Angel, a Web-based course management system for the public schools in this Midwestern state.

Discussion Topics

The discussion topics were selected or composed to not have simple absolute answers to facilitate argumentation. The questions were chosen from a textbook for Elementary Teachers written by Long, DeTemple, and Millman (2009).The discussion topics utilized were the following:

1. Suppose that you are the chief of maintenance for a large metropolitan hospital. You are trying to decide from what company to buy your next 5-year supply of light bulbs. Would you look to the company whose light bulbs have the greatest mean or the greatest median life? Explain your reasoning. (pg. 590, question 16)

2. Two sociologists mailed out questionnaires to 20,000 high school biology teachers. On the basis of the 200 responses they received, they claimed that fully 72% of high school biology teachers in the United States believe the biblical account of creation. Is their claim justified by this survey? Explain (pg. 591, question 23)
3. According to Garrison Keillor, all the children in Lake Wobegon are above average. Is this assertion just a joke, or is there a sense in which it could be true? Explain. (pg. 576, question 23)
4. One student puts either a black or a white marble into a sack, without the second student looking. The second student puts a white marble in the sack, shakes the sack, and then draws out one marble. Is the information helpful to guessing the color of the marble initially placed in the sack? (This is a problem posed by Lewis Carroll of *Alice in Wonderland* fame in his book *Pillow Problems*.) (pg. 659, question 20)
5. In a two-person game, player A rolls two ordinary dice with the faces of each die marked 1 through 6. Player B, however, uses number cubes with the faces of a red cube marked 1, 3, 4, 5, 6, 8 and the faces of a green cube marked 1, 2, 2, 3, 3, and 4. If the player rolling the higher total wins, would you prefer to be player A, or player B, or doesn't it matter? Explain. (pg. 659, question 21)

These questions relate to the Professional Development Series because they are questions dealing with data analysis and probability. The questions also invoke discussion because participants may reason in different ways about them, and bring different background knowledge to the discussion. The participants were to either support or oppose each of the questions and use Constraints Only or Constraints with Labels as they posted and replied to posts.

Dependent Measures and Research Questions.

Several dependent measures were utilized in this study. These dependent measures include the following: basic frequency analyses, argument category analysis, event sequence analysis, quality of response, and qualitative analysis of the discussions. In this section, the dependent measures will first be described, followed by an analysis of how these measures will be used to answer the primary research questions.

Specific Dependent Measures

Basic Frequency Analysis

This study utilized the same statistical analysis as Jeong and Joung (2007). Within the constraint conditions (Constraints Only and Constraints with Labels), two types of message frequencies are of particular importance: the number of messages challenging a post (Initial Challenges), and the number of posts responding to a challenge by another student (Challenge Rebuttals). In addition, we can consider the frequency of Initial Posts and Total Number of Posts.

The dependent variable examined for the Initial Challenges was the frequency of the challenging messages posted by other participants. The dependent variable examined in Challenge Rebuttals was the frequency of the initial participant responding back to other students' challenges. The number of Initial Posts, Initial Challenges, Challenge Rebuttals and Total Posts were compared across the two constraint conditions.

Posts across the constraints conditions

	Constraints Only	Constraints with Labels
Initial posts		
Initial challenges		
Challenge rebuttals		
Total posts		

Table2: Table to show the number of posts across the two constraints conditions.

Argument Category Analysis

Within each constraint condition, tallies were kept of each of the four argument categories (Argument, Evidence, Critique, and Explanation) in both the support and oppose groups. These tallies were done for each debate, as well as for across all debates (See Figure 7).

	Constraints Only		Constraints Plus Labels	
	Support	Oppose	Support	Oppose
Argument				
Evidence				
Critique				
Explanation				

Figure 7. Table describing breakdown of argument categories

Event Sequence Analysis

Event sequence analysis was used to identify prevalent patterns in message-response exchanges. Event sequence analysis was used to determine: 1) the probability in which a given message was able to elicit a specific type of response; and 2) the probability distribution of the types of responses elicited by each message type. Event sequence analysis has been effectively used in other research on group and inter-personal communication to study, for example, communication patterns in children at play (Bakeman & Brownlee, 1982), and mother and infant at play (Stern, 1974). This analysis will be based on the procedure used by Jeong & Joung (2007), and will look at the probability of each type of argument component following each other type of argument component.

Quality of Responses

The researcher examined the quality of the responses in each group. Evidence of critical thinking was examined in each of the participants' responses and in the discussion. Critical thinking was defined as the extent to which a response was meaningful and complete. In the highest response category, participants needed to conform to the appropriate constraint condition.

Two issues in quality of responses

1. Was there inter-relater reliability in judging quality of responses? 2. Did the Constraints plus Label and Constraints Only conditions differ in quality of responses?

Two coders (the researcher and an independent coder) classified the messages in all three groups to check inter-relater reliability and assigned a code to each message posted in the discussions. Participants' responses were coded using the following rating scale: 0 –post or response not meaningful; 1 – post or response addressed only part of the question; 2 – post or response followed the given constraint condition and fully addressed the question. The Cohen's κ test of the reliability of the coding was used for both the Constraints Only Condition and the Constraints with Labels Condition.

Pre and Post Test Results and Relationship with Argumentation

The pre- and post-tests were administered on a voluntary basis to all participants in the Professional Development Series, including participants in this study. The tests were used to determine the change in achievement (increase of content knowledge) of the participants in the Professional Development Series. For the purpose of this study, a comparison of the constraint conditions was performed. In addition, the relationships between post-test performance and argumentation quality and overall quantity of posts were examined.

Qualitative Analysis of Discussions

The primary goal of this analysis is to determine if there are any qualitative differences in the discussion posts of participants assigned to the two primary conditions. This analysis is exploratory in nature. Qualitative information might extend the quantitative results by considering in-depth specific characteristics about the quality of responses,

Relation of Research Questions to Dependent Measures

There were four primary research questions for the study. These questions were:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?
    i. The dependent measures used to assess this question include Basic Frequency Analysis and Argument Category Analysis.

2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations, counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?
    i. The dependent measure used to address this question is Event Sequence Analysis.
3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?
    i. This question is addressed by having independent raters assess the quality of responses
4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?
    i. This question is addressed through qualitative analysis of the discussions.

Summary

The current study examined the impact of message constraints and labels on collaborative argumentation in asynchronous online discussions. A basic frequency analysis was conducted to determine the number of messages challenging a post and the number of posts responding to a challenge by another student. An argument category analysis was conducted to determine the number of supporting and opposing posts or each of the four argument categories (Argument, Evidence, Critique, and Explanation) within each constraint condition (Constraints Only and Constraints Plus Labels). The quality of response was looked at for each group. Two coders classified the messages to check for inter-relater reliability. Pre- and Post-tests were administered to determine the change in achievement of the participants of the Professional Development Series. Event Sequence Analysis was used to identify prevalent patterns in message-response exchanges. Quantitative and qualitative results are discussed in the next chapter.

CHAPTER 4

Results

A mixed methods case study design is used to explore the effects of message constraints and Constraints with Labels on collaborative argumentation in asynchronous online discussions. Quantitative and qualitative methods are used to collect data allowing the researcher to make inferences about student's argumentation in online discussions. The results of both the qualitative and quantitative methods are presented here. A discussion of these results will follow in Chapter 5.

The major comparison will be between the Constraints Only and Constraints with Labels Conditions. However, three discussion groups were created to facilitate discussion. Due to the small number of participants, these groups were combined. However, a comparison of post types across Discussion Groups was first performed to determine if there were any differences.

Although Discussion Group B did not appear to be as much involved in the discussion, a one-way analysis of variance showed that there was no statistical difference in the number of initial posts ($F(2,22) = 1.954$, $p = .166$), the number of challenges ($F(2,22) = 1.253$, $p = .305$), the number of challenge rebuttals ($F(2,22) = 3.143$, $p=.063$), or the total number of posts ($F(2,22)=1.722$, $p=.202$). The total number of messages produced in the ten weeks of discussion was 31 in Discussion Group A, 5 in Discussion Group B, and 30 in Discussion Group C. Since the analysis of variance showed no difference between the three discussion groups, all results will be combined for further analysis. See Fig. 8

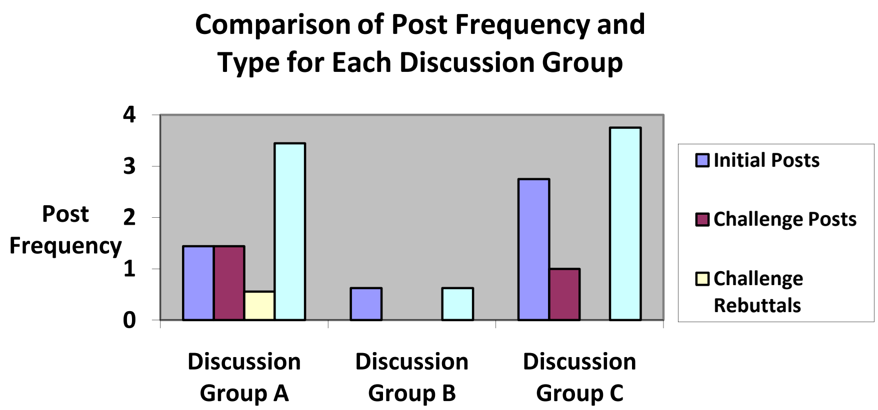


Figure 8: Comparison of Post Frequency and Type for Each Discussion Group.

In this chapter, the researcher first describes the quantitative analyses performed on the data collected from the online discussions. This section provides evidence used to answer the first two research questions:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?
2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations, counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?

The quantitative analysis only provides evidence as to whether or not there is a statistically significant difference when message constraints and Constraints with Labels are used in an online discussion.

Qualitative methods are used to assess if there are any differences in student use of argument in the Constraints Only Condition and the Constraints with Labels Condition in online discussions. These differences might include differences in the quality of the response, or other differences in argument structure. The qualitative analysis provides evidence to answer Research Questions 3 and 4.

3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?
4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?

Basic Frequency Analysis

Three major types of posts have been identified: initial posts, challenges and challenge rebuttals. For these post types, the participating teachers could post as they wished, within their assigned Constraint condition. In addition, the total number of posts was considered. The major concern was whether there were differences in the frequency of these types of posts depending on Constraints with Label Condition as compared to Constraints Only Condition. Participants were instructed about which constraint to use, and were instructed as to whether their posts should support or oppose posts to which they responded. For this analysis, all Discussion Groups are combined, because no differences were found among discussion groups.

For each of the post types, an independent samples t test was used to compare the Constraints with Label and the Constraints Only condition. Table 3 and Figure 9 show the means for these t tests.

	Initial Posts	Challenge Posts	Challenge Rebuttals	Total Posts
Constraints Plus Label	2.56	1.73	0.00	3.60
Constraints Only	1.96	2.14	0.77	4.21

Table 3: Mean number of post types in Constraint Conditions

There were no differences between the Constraints with Label and Constraints Only Condition for Number of Initial Posts ($t = .847$, $df = 23$, $p > .05$), the number of Initial Challenges ($t = -.631$, $df = 23$, $p > .05$), the number of Challenge Rebuttals ($t=-1.732$, $df=23$, $p =.09$), or the number of Total Posts ($t=-.069$, $df=23$, $p>.05$). There were no significant differences between Constraints with Label Conditions in any post type, although the analysis for the number of Challenge Rebuttals approached significance ($p=.09$), indicating a tendency for more Challenge Rebuttals in the Constraints Only Condition.

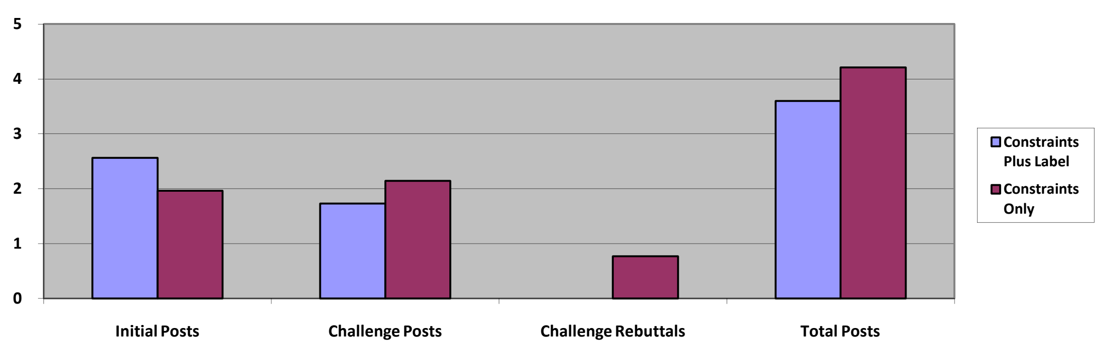


Figure 9: Means for Different Type of Posts by Constraint Condition

Argument Category Analysis

The goal of the Argument Category Analysis was to examine the overall frequency of each type of post in the different constraint conditions. This analysis is based on the post categories defined by Jeong and Joung's (2007) simplified version of Toulmin's model. Each post is identified in terms of one of Jeong and Joung's categories of Argument, Evidence, Critique and Explanation. This analysis answers portions of Research Questions 1 and 2, with an emphasis on labeling the type of individual post, rather than where that post fits within the argument structure. This analysis is a descriptive analysis which examines the number of times each argument component occurred under different conditions.

There were more opposing posts (42) than supporting posts (24). More posts were entered in the Constraints Only Condition (35) than for the Constraints with Label Condition (31). The argument category that was most frequent was Evidence (27) and the category that was least frequent was Critique (9). In the Argument category, more posts were entered in the Constraints with Labels Condition (13) than in the Constraints Only Condition (1).

	Constraints Only		Constraints Plus Labels	
	Support	Oppose	Support	Oppose
Argument	1			13
Evidence	13		2	12
Critique		7	2	
Explanation	6	8		2
	20	15	4	27

Table 4: Table describing breakdown of argument categories

In the Constraints with Labels Condition, there were 2 Critiques versus 7 Critiques in the Constraints Only Condition. However, Critique and Argument appear to be the categories that would most often be a challenge to another person's post. These types of posts nearly always occur when a person is assigned to "oppose" regardless of the

Constraint Condition. Using Constraints with Labels increased the number of Argument Posts.

Event Sequence Analysis

In addition to identifying the frequency of individual types of argument components, as described in the previous section, it is important to consider the sequential nature of argument, and to consider sequences of posts. This is the goal of event sequence analysis. Jeong and Joung (2007) used an exploratory event sequence analysis to describe the probability of each possible two-post sequence with the argument components of Argument, Evidence, Critique and Explanation.

Event sequence analysis was used to identify prevalent patterns in message-response exchanges. Event sequence analysis was used to determine: 1) the probability in which a given message was able to elicit a specific type of response; and 2) the probability distribution of the types of responses elicited by each message type. This analysis was used to consider whether the nature of the discussion changed in the different Constraint Conditions. Although the numeric probabilities may be different across conditions, probabilities within a condition are interdependent (e.g., they must add up to 1.00), and looking at the entire pattern of sequences, as described in Table 5 and Figure 10 is most appropriate. The descriptive analysis of argument structure is a qualitative analysis of the nature of discussion, and thus is related to Research Question 4. Only two-post sequences are considered, as in most cases discussions did not go beyond a two-post sequence.

Analysis of message sequence probabilities

Given the finding that participants were less likely to critique other participants and respond back to critiques, additional descriptive analyses were conducted to determine if this pattern of interaction significantly affected the types of messages students contributed to the debates. Constraints with Label Condition and Constraints Only Condition are compared in Table 5.

	Second Post	ARG	EVID	CRIT	EXPL	Reply	Total Posts	Rate	Proportion Reply	Proportion of Total Posts
	First post									
Constraints with Label	ARG	0.00	0.11	0.00	0.00	6	13	0.46	0.67	0.41
	EVID	0.22	0.00	0.00	0.00	3	15	0.20	0.33	0.42
	CRIT	0.00	0.22	0.00	0.00	0	2	0.00	0.00	0.06
	EXPL	0.44	0.00	0.00	0.00	0	2	0.00	0.00	0.06
						9	32	0.28		
Constraints Only	ARG	0.00	0.12	0.00	0.00	0	1	0.00	0.00	0.03
	EVID	0.00	0.06	0.24	0.18	8	11	0.73	0.47	0.32
	CRIT	0.00	0.24	0.00	0.06	5	7	0.71	0.29	0.21
	EXPL	0.00	0.06	0.00	0.00	4	15	0.27	0.24	0.44
						17	34	0.50		

Table 5: Transitional probabilities, number of replies, number of messages per category, relative frequency of replies elicited per category, and relative frequency of messages per category

In the Constraints with Label Condition, 41 percent of the posts were arguments compared with three percent in the Constraints Only Condition. For the Constraints Only Condition, the two most frequent types of posts were Explanation and Evidence.

To examine transitional probabilities, consider the first cell in the table. This cell indicates that for the Constraints with Label Condition, there were no instances in which Arguments followed Arguments. However, Arguments followed Evidence two out of nine times (22 percent of the total replies).

From the table of transitional probabilities (Table 5), comparing the Constraints with Label and Constraints Only Conditions, it is obvious that there were more replies and more total posts in the Constraints Only Condition. The proportion of replies to total posts was also higher in the Constraints Only Condition (0.50) than in the Constraints with Label Condition (0.28).

For the Constraints with Label Condition, there were no replies (second posts) that were critiques or explanations regardless of the type of the first post. In the Constraints Only Condition, critique posts only followed evidence. Explanations followed Evidence and Critique posts.

In the Constraints Only Condition, Arguments never occurred as a second post (reply) regardless of the type of first post. In the Constraints with Label Condition, Argument only followed Evidence and Explanation.

For the Evidence second posts (replies), proportion of the type of post responded to was nearly identical in the Constraints with Label and Constraints Only Conditions for Arguments and Critique first posts. In the Constraints Only Condition, a small proportion of Evidence second posts followed evidence and explanation first posts.

Overall, there were more replies/second posts for the Constraints Only Condition. The exception is in the Argument reply to a first post. The Constraints with Label Condition was more likely to use Arguments as a type of reply. Possibly participants defined the types of posts in different ways, or were more likely to use arguments when forced to use Constraints with Labels for all four argument categories.

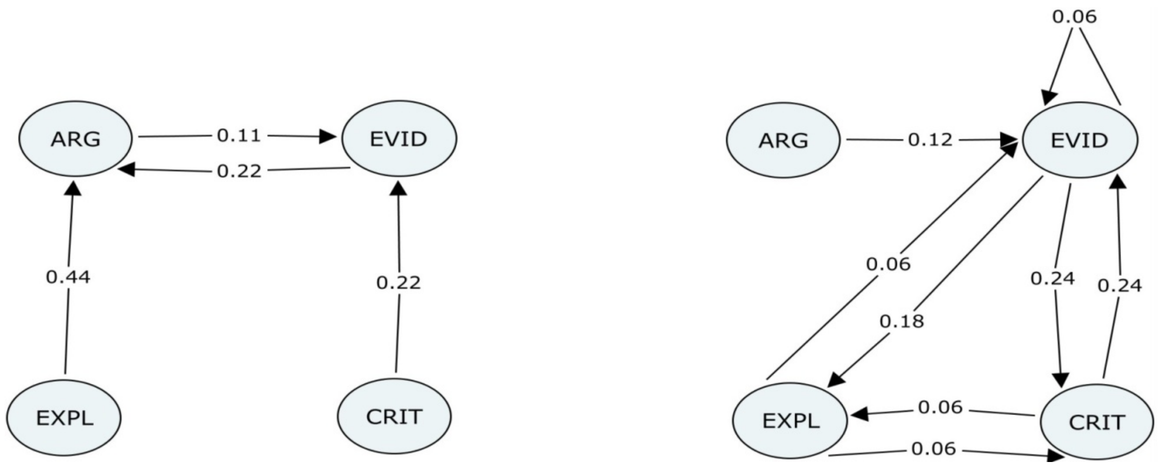
To conduct a closer examination of some of the specific processes (or message-response sequences) that can be used to demonstrate or measure higher levels of critical analysis, a descriptive analysis was conducted to test for possible differences between the three groups on the percentage of (a) evidence replies to argument (ARG →EVID), (b) explanatory replies to argument (ARG →EXPL), (c) argument replies to evidence (EVID →ARG), (d)critique replies to evidence (EVID →CRIT), (e) explanatory replies to evidence (EVID →EXPL), (f) evidence replies to critique (CRIT →EVID), (g) explanatory replies to critique (CRIT →EXPL), (h) argument replies to explanatory (EXPL →ARG), (i) evidence replies to explanatory (EXPL →EVID), and (j) critique replies to explanatory (EXPL →CRIT). Table 6 shows the percentages of responses to constraints for each of the two constraint conditions. This is a simplified version of Table 5. Table 6 shows only non-zero probabilities and shows directly the two-post sequence in the left column.

	Constraints with Label	Constraints Only
ARG → EVID	0.11	0.12
EVID→ CRIT	.	0.24
EVID→EXPL		0.18
EVID→ EVID		0.06
EVID→ARG	0.22	
CRIT→ EVID	0.22	0.24
CRIT→EXPL		0.06
EXPL → ARG	0.44	
EXPL→EVID		0.06
EXPL→ CRIT		0.06

Table 6: Percentage of given messages with specific targeted replies

The analysis of the probability of two-post sequences in the different constraint conditions allows us to partially answer Research Question 4 about the qualitative nature of the discussion. When labels are required, there are less different types of two-post sequences. Evidence was used less often as a first post.

The transitional probabilities in Table 6 were converted into a transitional state diagram for the Constraints with Labels and Constraints Only Conditions (see Figure 10). The diagrams provide a visual illustration of how frequently participants responded to given types of messages when participants chose to respond to a message.



Constraints with Labels   Constraints Only

Figure 10. Transitional state diagrams of the observed message response interactions with transitional probabilities.

In the Constraints with Labels Condition, Critiques and Explanations never followed any type of post. Arguments followed Evidence for 22 percent of the posts, while Evidence followed Argument for 11 percent of the posts. Evidence followed Critique for 22 percent of the time. The most frequent sequence for the Constraints with Labels was Argument following Evidence, which accounted for 44 percent of the posts.

In the Constraints Only Condition, the posts were more evenly spread across the sequence possibilities. Explanations never followed Argument. However Explanation occurred as a response to Evidence for 18 percent of the posts, and followed Critique for 6 percent of the posts. Arguments never occurred as a response to any type of post. Evidence occurred as a response to Argument posts 12 percent of the time, to Evidence posts 6 percent of the time, to Explanation posts 6 percent of the time, and to Critique posts 24 percent of the time. Critique posts occurred as a response to Evidence posts 24 percent of the time, and to Explanation posts 6 percent of the time.

Quality of Responses

Question 3 addresses the quality of responses in the Constraints with Label and Constraints Only Conditions. For this analysis, each of the discussion responses was categorized in terms of the quality of the response. The coding scheme was as follows

0 = post or response not meaningful;
1 = post or response addressed only part of the question;
2 = post or response followed the given constraint condition and fully addressed the question.

There were 32 total posts from the Constraints with Label Condition and 35 total posts from the Constraints Only positions.

Two coders (the researcher and an independent coder) classified the messages in all three discussion groups to check inter-relater reliability. The raters assigned a code to each message posted in the discussions, using the following rating scale: 0 –post or response not meaningful; 1 – post or response addressed only part of the question; 2 – post of response followed the given constraint condition and fully addressed the question.

From Discussion 2: Suppose that you are the chief of maintenance for a large metropolitan hospital. You are trying to decide from what company to buy your next 5-year supply of light bulbs. Would you look to the company whose light bulbs have the greatest mean or the greatest median life? Explain your reasoning. The following post was made by a participant who was to give supporting evidence in support of the greatest mean life: "You must purchase the lightbulbs with the greatest mean life since it would be the average life of all the bulbs. You want all your bulbs to have a long life so the mean gives all of them to you."

Coder 1 labeled this post as a 1, as the post addressed only part of the question. Coder 2, on the other hand, noted the words "greatest mean", "average life of all the bulbs", and "mean fives all of them to you" as evidence supporting the question. Another participant posted the following response to another participant's post, "I think the greater number of bulbs will have a larger effect then a smaller number". Coder 1 labeled this response as a 1, addressing only part of the question. Coder 2 labeled this response as a 2 since it followed the constraint condition and fully addressed the question by using such phrase s as "greater number of bulbs" and "larger effect".

Discussion 3: One student puts either a black or white marble into a sack, without the second student looking. The second student puts a white marble in the sack, shakes the sack, and then draws out one marble. Is the information helpful to guessing the color of the marble initially placed in the sack? (This is a problem posed by Lewis Carroll of *Alice in Wonderland* fame in his book *Pillow Problems*.)

In response to this question, the following posts were made by two participants. Coder 1 rated them 1 as addressing only part of the question, whereas Coder 2 labeled them 2, that the post followed the given constraint and fully addressed the question.
Participant 1: The person drawing out from the sack does know all possibilities.
Participant 2: It certainly would be helpful if you could repeat the scenario several times.

Examples of postings:

0: A participant responded by saying "true" to a post.

1: In response to a posting, a participant stated "Player B has two 3's on one die. Player B could also role a 11 two ways." Another participant in response to a posting stated: "I listed out the outcomes but multiplied, oops. I need to go back and reply to my own post!" The same participant later posted the following response: "Good question, I listed it as one possibility."

2: In response to a posting for the dice discussion, a participant replied: "What kind of an advantage would this be? Do you mean by advantage that the outcomes are somehow weighted? Is it more likely that the 8 will appear more than others? If that is your belief, then the 3 would give an advantage more than the 8."

The Cohen's κ test of the reliability of the coding (Cohen, 1960) was used for both the Constraints Only Condition and the Constraints with Labels Condition. Cohen's K was calculated to be 0.91. (simple Cohen's K). The chance-corrected Cohen's K was 0.66. Although somewhat low, given the nature of the rating task, this was considered to be an acceptable reliability rating (Howell, 1997).

There were no differences in quality ratings between the Constraint Conditions. For the principal investigator, quality ratings for posts did not differ between the Constraints with Label Condition (M = 1.719, SD = 0.581) and the Constraints Only Condition (M = 1.886, SD = 0.323, independent samples t = -1.470, df = 65, p = .146). Similar results were found for the second rater (t = -.955, df =65, p=.343).

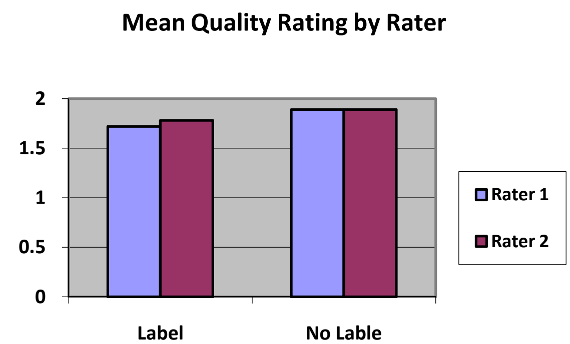


Figure 11: Mean quality rating by rater.

Qualitative methods

Qualitative methods are used to examine the responses to the discussion questions within this multiple case study design. The goal is to identify whether there are differences in the two constraint conditions in participants' tendency to critique others within a discussion. Qualitative methods are also used to provide insight as to whether or not participants will respond to an argument with a critique, explanation, or evidence. Because the constraint conditions were distributed across three discussion groups, and participation varied across the groups, each discussion group will be discussed separately, with specific attention to participation within the constraint conditions. Each group discussed the same five topics pertaining to data analysis and probability. Each group participated in an asynchronous exchange of messages. Each discussion was made available to the participants for two weeks. The time between postings was several hours to days because of the teaching assignments of the participants.

Group A

Group A had a total of thirty-one postings over the five discussion questions. Only two of the thirty-one postings were Constraints with Labels. These Constraints with Labels postings were made by the same participant and one in each of the first two discussion questions. The constraints used by this group were $EXPL_o$, $CRIT_o$, ARG_s, $EVID_s$, and $EVID_o$. Dialogue followed the constraints and the topic. The following remarks during the first discussion exemplify the explanations, evidence, and critiques that occurred throughout the entire process.

Discussion 1: In a two-person game, player A rolls two ordinary dice with faces of each die marked 1 through 6. Player B, however, uses number cubes with the faces of a red cube marked 1, 3, 4, 5, 6, 8 and the faces of a green cube marked 1, 2, 2, 3, 3, 4. If the player rolling the higher total wins, would you prefer to be player A, or player B?

A1F: I would prefer to be player B. The die with an eight on it would give an advantage.

A2M (replies): “What kind of an advantage would that be? Do you mean by advantage that the outcomes are somehow weighted? Is it more likely that the 8 will appear more than others? If that is your belief, then the 3 would give an advantage more than the 8.”

A1F (replies to A2M): “You said, ‘a single 8 on player B’s die is already greater than two die combinations that add up to 7 or less. This means that a single die beats 21 of the 36 possible two dice combinations for player A.’ That could be a definite advantage for player B. How many times are we rolling? That could be a big factor.

F is female M is male

Another exchange took place within the same group. This exchange was started five hours and thirteen minutes later. A2M replied to this posting four minutes before replying to A1F’s posting on the same day.

A3F: The sample space of both outcomes (player A and player B) show identical possibilities for outcomes. The sums both have equal chances of rolling a 2 or 12, which would be 1 out of 12. The probability of rolling a 3 or 11 for either player is 5 out of 36. Either player would have the probability of rolling a sum of 4 or 10 of 3 out of 36, or 1 out of 12. The probability of rolling the sum of 6 or 8 would be 5 out of 36 for either player and the probability of rolling a 7 for each player would be 6 out of 36 or 1 out of 6.

A2M (replies): Although the distributions are the same, don't forget that a single 8 on player B's die is already greater than the two dice combinations that add up to 7 or less. This means that a single die beats 21 of the 36 possible two dice winning combinations from player A.

A4F (replies to A2M): Even though the 8 is larger on the die, the second die has more smaller numbers that actually repeat so your sums will be smaller. On the second die there is not a 5 or 6 so your sum would not be as large as the roll of player A.

Group B

Group B's participation was extremely limited with a total of only four asynchronous messages between three members of the group. These four postings were made in two of the discussion questions, with one question receiving three posts and another question receiving a single posting. There was no interaction as each of the members posted and did not re-enter the discussion. Each post was Constraints with Labels. One post cited a website addressing the topic and used to support evidence in the post. Two posts included the spreadsheet used to determine the sum of the rolls of the die in the first discussion.

Group C

Group C had a total of thirty-seven postings over the five discussion questions. Nineteen of the thirty-seven postings were Constraints with Labels. Four of the responses were posted by a member of another group, two postings by one member of group B and two postings by one member of group A. The constraints used by this group were $EXPL_o$, $EXPL_s$ ARG_o, $CRIT_o$, and $EVID_o$. Dialogue followed the constraints and the topic. The following remarks during the second discussion exemplify the explanations, arguments, evidence, and critiques that occurred throughout the entire process.

Discussion 2: Suppose that you are the chief of maintenance for a large metropolitan hospital. You are trying to decide from what company to buy your next 5-year supply of light bulbs. Would you look to the company whose light bulbs have the greatest mean or the greatest median life? Explain your reasoning.

C1F: I suppose that the hospital will buy a lot of light bulbs. So any outliers won't have a drastic effect on the mean like they might for a small number of bulbs. Therefore mean will be more representative of the life of the typical bulb.

C2F (replies to C1F): The mean would be greatly affected by bulbs that arrived broken and were unable to be used. However if you looked at the median the broken bulbs would have no impact.

C5M (replies to C1F): I think the greater number of bulbs will have a larger effect then a smaller number.

A second exchange between these same three participants was initiated by C5M two minutes before he responded to C2F's posting.

C5M: Mean can be affected by extreme low or high numbers. Median is a better way to look at the middle. The median is not affected by such extreme numbers since you are not using a sum but rather the number of pieces of data to find the middle.

C2F (replies toC5M): Knowing this information, why would a company ever use mean to report their statistics?

C1F (replies to C5M): I agree that mean can be affected by extreme high or low numbers and that an outlier would greatly affect the mean of a small group of numbers, but given that a hospital must order a large number of light bulbs, the number and kind of outliers would be negligible.

For further discussions, see Appendices B through F.

In comparing groups A, B, and C, no difference was found between the discussion groups. The intent was to have equal Constraints with Label and Constraints Only participants within each group. Table 7 depicts the number of participants from each of the three discussion groups that were assigned to the Constraints with Label Condition or the Constraints Only Condition along with their number of postings. According to the posts within each group, the discussions in Group A were mainly between individuals in the Constraints Only Condition. Group A was composed of five participants (one in the Constraints with Labels Condition and four in the Constraints Only Condition) who posted thirty-one times to the discussions. The participant who was assigned to the Constraints with Labels Condition contributed two postings across all five discussions. Group A was basically a Constraints Only Condition.

In Group B, only three people participated and all postings were from participants assigned to the Constraints with Labels Condition. Group C was composed of five participants (four assigned to the Constraints with Labels Condition and one assigned to the Constraints Only Condition) who posted thirty-one times to the discussions. The participant in the Constraints Only Condition contributed seven postings throughout the five discussion topics. Group C was basically a Constraints with Labels Condition.

	Participating Individuals	Posts in Constraints with Labels Condition	Posts in Constraints Only Condition	Total
A	5	3	28	31
B	3	5	0	5
C	5	23	7	30
Total	13	31	35	

Table 7: Actual number of individual posts for each group in the Constraints with Labels/Constraints Only condition.

Qualitative Results Conclusion

This study examined the effect of message constraints and Constraints with Labels within three small groups of middle and secondary school mathematics teachers. Data was collected by observing the interactions between group members in discussions. The discussions in all three groups were limited to an asynchronous bulletin board system. Group B was the only group that did not interact. It had the least amount of participation amongst the groups, with only three members contributing to the effort, and only four messages being posted on two of the five discussion questions.

There was interaction between the participants of the remaining two groups. Group A addressed all the discussion questions, with the first two questions receiving the majority of the twenty-seven postings by this group. Of the 15 replies by this group, none were Constraints with Labels. This shows that participants' using a constraint with a Constraints with Labels did not want to challenge another participants' message. On the other hand, Group C addressed all the discussion questions and had some interaction in each discussion. Of the 16 replies by this group, all were Constraints with Labels. This finding shows that constraints with Constraints with Labels did not significantly lower participants' tendency to challenge other participants' messages.

Chapter Conclusions

The research questions addressed in this study were:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?

In the basic frequency analysis, there were no differences between the Constraints with Labels Condition and the Constraints Only Condition for the number of initial posts, the number of challenges and the number of challenge rebuttals.

In the argument category analysis, there were more Argument posts in the Constraints with Labels Condition than in the Constraints Only Condition (13 versus 1). There were more Critique posts for the Constraints Only Condition (5) than for the Constraints with Labels Condition (2). There were more Explanation posts for the Constraints Only Condition (14) than for the Constraints with Labels Condition (2). Overall there was not much of a difference in the total number of posts for each condition (35 for Constraints Only Condition and 31 for Constraints with Labels Condition).

2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations, counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?

   The evidence related to this question comes from both the Basic Frequency Analysis and from the Event Sequence Analysis. There were no significant differences in the Basic Frequency Analysis. However, there was a tendency for more challenge rebuttals to occur in the Constraints Only Condition. When examining two-post sequences (the Event Sequence Analysis) Critiques and Explanations never followed any type of post in the Constraints with Label Condition. The primary types of responses were Arguments in response to Explanation, Argument following Evidence, and Evidence following Critique. In contrast, in the Constraints Only condition, Arguments never followed Explanations. The other types of two sequence posts were more evenly distributed in the Constraints Only Condition. Thus the nature of the discussion appears to be qualitatively different in the Constraints with Label condition.

3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?

   Two raters assessed the quality of responses. There was no difference in quality of posts between the Constraints Only and the Constraints with Labels Condition.

4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?

   Constraint Conditions were not equally distributed across the three discussion groups. However, discussion group differences in terms of actual participation made Group A primarily a Constraints Only Condition, Group C was a Constraints with Label Condition, and Group B saw overall low participation. There were no differences in post frequencies (in overall posts, challenges and challenge rebuttals) across the discussion groups, indicating no difference in Constraint Conditions. The sample sizes were relatively small, and there may be individual differences among participants in the discussion groups which impact their level of comfort with using argument category constraints and labels.

This question is perhaps better addressed in the Event Sequence Analysis, which shows differences in the probability of two-post sequences in the Constraint Conditions (Figure 10).

Chapter 5

Conclusion

Comparison to Jeong and Joung.

Jeong and Joung Study

This study investigated the role message constraints and labels play in fostering online discussion among mathematics teachers participating in professional development related to teaching statistics and probability. This study extends Jeong and Joung's work on argument constraints in online discussion. Jeong and Joung found that students who used labels on their messages were less likely to challenge other students and less likely to respond back to challenges from other students.

The major finding of Jeong and Joung was the difference between the Label and No Label Groups. Jeong and Joung found that 41% of all messages posted by students in the Label Group were Argument. However, the authors found that 35% of postings from the No Label Group were Argument. In addition, Jeong and Joung found that 10% of all messages posted by participants in the Constraints with Labels Condition were Evidence and 26% of all messages posted by participants in the Constraints Only Condition were Explanation.

Overall, for the Jeong and Joung study, the proportion of replies to posts was 67 percent in the No Label Condition versus 55 percent in the Label Condition. The Jeong and Joung study looked at how often Argument occurred as a reply to all types of posts in the Label and No Label conditions. The Jeong and Joung study found that a relatively low percent (under 10%) of Argument posts were replies to all other types of first posts.

In the Constraints with Labels condition, Jeong and Joung found that Argument posts never followed Evidence posts. In the Jeong and Joung study, Argument posts followed Explanation posts 22 percent of the time. In Jeong and Joung, Argument followed Argument posts 21 percent and Argument followed Critiques posts13 percent of the time.

Jeong and Joung used coders to determine if participants labeled correctly, by having trained coders independently assign label to the responses, and comparing to participant labels. This resulted in relatively good agreement between the participants and the coders, indicating that participants were able to use labels correctly.

The findings in this study replicated Jeong and Joung in that 41% of all messages posted by students in the Label Group were Argument. However, only 3% of the messages posted in the Constraints Only Condition were Argument. In addition, in the current study 42% of all messages posted by participants in the Constraints with Labels Condition were Evidence and 44% of all messages posted by participants in the Constraints Only Condition were Explanation.

Overall, the proportion of replies to posts was higher in the Constraints Only Condition than in the Constraints with Labels Condition. The proportion of replies to posts in the Constraints Only Condition was 50 percent for this study compared to 28 percent in the Constraints with Labels condition. This study also looked at how often Argument occurred as a reply to all types of posts in the Constraints with Labels and the Constraints Only Conditions. In the Constraints Only Condition, Argument never occurred as a reply regardless of the type of first post.

In the Constraints with Labels condition, Argument posts followed Evidence posts 22 percent of the time and Explanation posts 44 percent of the time. In the current study, Argument posts never followed Argument posts or Critiques posts.

Current Study

In the current study, the raters addressed the quality of the discussion responses. Relatively good agreement was found between the raters (k=0.66). In addition, no difference was found between the Constraints with Labels and Constraints Only Conditions.

The current study expanded on Jeong and Joung by doing a qualitative analysis of the discussions. Although the initial design included participants from each Label condition in each discussion group, Group A became a Constraints Only Condition and Group C became a Constraints with Labels Condition. There were more overall posts in Group A (32) compared to Group C (31), and more Constraints Only posts (20 for Group A compared to 7 for Group C). There were more Constraints with Labels posts in Group C (24) compared to Group A (3).

Total postings decreased for both the Constraints with Labels and Constraints Only Conditions as the discussions were introduced to the study. Discussion 1 had the largest number of postings with twenty-seven posts. The last discussion (Discussion 5) had a total of 6 postings. The greatest decrease in postings was observed from the second to the third discussion, with a decrease of twelve postings. A slight increase in postings was then observed in Discussion 4.

Message constraints and labels were based on previous research by Jeong and Joung. Jeong and Joung's argument constraints were based on a simplified version of Toulmin's model of argumentation. Toulmin's model included six types of warrants (including generalization, sign/clue, causal authority, and principle). Jeong and Joung simplified this to the four categories of Argument, Evidence, Critique, and Explanation. Jeong and Joung found that students who used labels on their messages were less likely to challenge others students, and less likely to respond back to challenges from other students. In addition, they examined transitional probabilities.

The issue was whether Jeong and Joung's previous findings would extend to mathematics education. Mathematics education might be different because mathematics students and instructors may be more familiar with formal alrgumentation, and often use discourse in the educational process. Jeong and Joung suggested that perhaps the use of labels such as Critique and Argument might have negative connotations and inhibit certain types of responses. In addition, Jeong and Joung had separate Label and No Label discussion groups, rather than combining the Label and No Label conditions in a single discussion group, as was done in the current study.

The goal of the current study was to examine the role of message constraints and labels on argumentation in an asynchronous online discussion. The primary research questions were:

1. Do message constraints with labels increase or decrease the mean number of times a student critiques and challenges messages posted by other students as compared to students who do not label their responses within online staff development with middle school and high school mathematics teachers?
2. Do message constraints with labels increase or decrease the number of times a student responds back to critiques with rebuttals to provide explanations,

counter-critiques, and additional evidence to defend claims as compared to students who do not label their responses?

3. Is the quality of responses different for the Constraints with Labels and the Constraints Only conditions?
4. Does qualitative analysis of discussions suggest any other differences between the Constraints with Labels and the Constraints Only conditions?

In the current study, there were 25 participants. These participants were middle school and secondary mathematics teachers enrolled in a Professional Development Series. These participants volunteered to take part in five optional online discussions. Participants were divided into three discussion groups, and assigned to one of two constraint conditions (Constraints Only or Constraints with Labels). When posting to the online discussions, they were asked to use argument constraints of Evidence, Argument, Critique or Explanation (based on Jeong and Joung's adaptation of Toulmin's model). In the Constraints Only Condition, they were simply required to use those constraints when they posted. In the Constraints with Labels Condition, they were required to label each post with the appropriate post category. Dependent variables included many that were not considered by Jeong and Joung, including basic category analysis, argument category frequencies, transitional probability (event sequence) analysis, ratings of response quality, and qualitative analysis of discussion processes.

To answer research question 1, the basic frequency analysis and the argument category analysis was used. The primary question was whether the impact of Constraints with Labels increased or decreased the number of times a student critiques and challenges messages posted by other students as compared to students who used Constraints but not

Labels. In the basic frequency analysis, there were no differences between the Constraints with Labels Condition and the Constraints Only Condition for the number of initial posts, the number of challenges and the number of challenge rebuttals. In the argument category analysis, there were more Argument posts in the Constraints with Labels Condition than in the Constraints Only Condition (13 versus 1). There were approximately equal posts in the Evidence category for both conditions (13 for Constraints Only and 14 for Constraints with Labels). There were more Critique posts for the Constraints Only Condition (5) than for the Constraints with Labels Condition (2). There were more Explanation posts for the Constraints Only Condition (14) than for the Constraints with Labels Condition (2). Overall there was not much of a difference in the total number of posts for each condition (35 for Constraints Only Condition and 31 for Constraints with Labels Condition). The biggest differences were in the Argument category, in which there were more posts in the Constraints with Labels Condition, and in the Explanation category, in which there were more posts in the Constraints Only Condition). For the Critique category, there were more posts in the Constraints Only Condition (7) than in the Constraints with Labels Condition (2). Overall the use of specific argument categories appears to differ across the two conditions. When asked to label their category, participants were not reluctant to label their post as Arguments or Evidence, but were more unlikely to describe their posts as Explanations and Critiques.

For research question 2, of interest was the extent to which a participant responded back to a challenge post with a rebuttal. The evidence related to this question comes from both the Basic Frequency Analysis and from the Event Sequence Analysis. There were no significant differences in the Constraints Only and the Constraints with Labels

Conditions in the Basic Frequency Analysis. However, there was a tendency for more challenge rebuttals to occur in the Constraints Only Condition.

In the Event Sequence Analysis, two post sequences were examined, and the results indicated that that there were differences between the Constraints Only and the Constraints with Labels Condition. When labels were required, Critiques and Explanations never followed any type of post. The primary types of responses were Arguments in response to Explanation, Argument following Evidence, and Evidence following Critique. In contrast, in the Constraints Only condition, Arguments never followed Explanations. The other types of two sequence posts were more evenly distributed in the Constraints Only Condition. Thus the nature of the discussion appears to be qualitatively different in the Constraints with Label condition.

Research question 3 addressed the quality of responses between the two conditions, based on ratings of quality from two raters. Quality of posts was the same across the Constraints Only and the Constraints with Labels Condition.

For Research question 4, the primary analysis was a qualitative analysis of the discussions. Although the intent was to have constraint conditions distributed equally across the three discussion groups, this did not occur. There were no differences in post frequencies across the groups. The sample sizes were relatively small, and there may be individual differences among participants in the groups that impact their level of comfort with using argument category constraints and labels. This question is also addressed in the Event Sequence Analysis, which shows differences in the probability of two-post sequences in the Constraint Conditions (Figure 10).

Is math different?

In Chapters 1 and 2, it was argued that participants in mathematics discussions might be differently impacted by message constraints and labels than those in other fields. This argument was based on the focus in mathematics classrooms on formal discourse and argument structure. In the current study, the impact of message constraints and labels on online discussion posts was explored. Important differences between the results of this study and the previous study of Jeong and Joung (2007) indicate that math might be different.

This question can be examined by considering the primary differences between Jeong and Joung's results and the current findings. Two types of analyses will be considered. The first is the mean number of posts per student involving challenges and challenge rebuttals in the Constraints Only and the Constraints with Label Condition. The second is the Event Sequence Analysis of two-post sequences.

With regard to the mean number of posts per student involving challenges, the Constraints with Label Condition did not appear to differ much between the current study and Jeong and Joung (1.73 challenges versus 1.80 challenges). For the Constraints Only Condition, the current study had 2.14 mean challenges versus 5.21 in Jeong and Joung, indicating that for this group of individuals, the use of Constraints Only did not increase the number of posts over Jeong and Joung's results. For posts involving challenge rebuttals, in the Constraints with Label Condition, there were no posts in the current study versus a relatively small number of posts (.87) in the Jeong and Joung study. In the Constraints Only Condition, the current study found that there was an average of .77 challenge rebuttal posts versus an average of 2.43 in Jeong and Joung.

Some caution should be taken in interpreting these differences. Although the mean number of challenges and challenge rebuttals appears to be less for teachers discussing mathematics than for preservice teachers discussing educational technology, the context and type of discussion needs to be considered. Jeong and Joung's participants were required to participate as part of a course, and were required to post a minimum of four messages per debate. This finding increased the total number of posts to more than 200 in all condition. In addition, the group sizes in Jeong and Joung were larger than in the current study (14), allowing for more possibilities to respond to another student. These differences make direct comparisons of means problematic.

In terms of the event sequence analysis, there were similar issues with interpretation and direct comparison due to discussion group size. In general, the overall pattern of two post sequences was much less complex in the current study, with some types of two post sequences not occurring at all. This was most evident in the Constraints with Label Condition. It appears that for this context of mathematics discussion, that using constraints with labels does not improve discussion over constraints only. Discussion patterns in the Constraints Only Condition in the current study were more complex than in the Constraints with Labels Condition. The absence of a control condition in which neither constraints nor labels were used makes it impossible to make generalizations about the overall impact of constraints only.

Limitations of the study

The limited sample for this study may not be representative of the population, however, the sample is knowledgeable about mathematics, and participation was voluntary. This study may not represent what happens in a classroom situation where postings are required for grade. Students in a classroom setting would potentially respond to each other more quickly. The timing of posts could be controlled by limiting the time frame for discussing. The discussion topic could be opened for one day or a weekend instead of the two-week time frame for this study. In addition, the specific discussion questions chosen could have an impact on the discussion process and the responses, and thus might not generalize to other types of questions.

An additional issue that was problematic in the current study was the assignment of participants in the Label and No Label conditions to the same discussion groups. This led to diffusion of the treatments across the groups – some individuals in the No Label condition used Labels, and some individuals in the Label condition did not label. Perhaps more training in the argumentation model and practice in the use of labels might be necessary. In addition, students who are trained in collaboration and cooperative learning seem to better understand arguments as used in a threaded discussion.

Potential Extensions of the Study

The current study used Jeong and Joung's simplified version of Toulmin's model to define the constraints and labels for argument structure. It is possible that this system of constraints and labels is relatively easy to use and remember. However, considering the use of Toulmin's full model, or of competing argumentation systems such as Erduran, Simon, and Osborne (2004) and Mitchell and Riddle (2000) might be useful. Erduran et.al. (2004) adapted Toulmin's model of argumentation to dialogic argument in the classroom. Their framework elaborates on Toulmin to scrutinize the extent to which elements of an argument are present to evaluate the quality of argumentation during small group discourse. The group's framework characterized the argumentative operations of each conversational turn during dialogue episodes. These argumentative operations include opposing, elaborating, reinforcing, and advancing claims along with adding qualifications.

While most argument systems intend to be general and to apply to all domains, one area of research might be to determine whether specific models or variations might be more useful in different domains. The use of argumentation systems or models has been explored in areas as diverse as medicine and law, as well as mathematics. Some comparison of different models across domains has been done, but a theory that can predict what would work best in each domain has not yet been established.

In addition, the use of threaded discussions for argumentation is relatively common. However, this format may not explicitly represent argument structure in a way that facilitates use of argument categories, even when labels are used. Researchers have been exploring different ways of representing argument structure. For example, Okada and Shum (2008 in press) focused on the potential of evidence-based dialogue maps as a research tool to investigate scientific argumentation among teenagers. Developed over twenty years by Conklin to build shared understanding during discussions, dialogue mapping is a knowledge mapping technique. Using this technique, students engage in action learning with their maps representing, visualizing, reflecting, and improving their arguments in a spiral design. Okada and Shum, (2008) found that evidence-based dialogue maps helped the classroom teacher to visualize well-structured maps with poor argumentation and poorly structured maps with good argumentation entrenched in the labels of nodes.

An alternative argumentation representation is utilized in SciNews Online. SciNews online is a collaborative research environment that includes a component called Notebook that addresses argumentation. The Notebook component supports note taking by revealing the four key elements of the ideal scientific argument structure, namely evidence, warrants, backings, and conclusions. A feedback image and a guiding question are used in each note-taking section to encourage learners to take notes during exploration, reading, or writing activities.

It appears that research on the use of argumentation models in online discussions is a relatively new domain, with many potential areas to be explored. In addition to the specific argumentation model and representation system used, and the potential for different models to be useful in different domains, the exploration of such models and the use of constraints and labels within such models is not limited to mathematics or even to education, but could be applied in other areas as well. Constraints and labels could also be incorporated into courses that require journaling, such as nursing and other science disciplines. Message constraints and labels could possibly diminish some of the problems with coding and analyzing the patterns between messages.

Additional Considerations

It appears that the research on the use of argumentation models in online argumentation is a growing field, with many potential avenues to explore, including different argumentation models, different domains, different representation systems, and potentially the match between model, representation system and domain.

However, in practical terms, unless students are explicitly required to use message constraints and labels, (and indeed argumentation systems in general) they are unlikely to do so, and requiring them to label may reduce their postings. The potential explanations for resistance to constraints and labels may have to do with negative connotations of some of the labels, but may also have to do with the cognitive load associated with using labels and constraints while composing posts. This is another potential area of research.

The goal of educators in exploring the use of argumentation models is to improve the quality of posts and responses, but a balance needs to be found in terms of how to best support students in maintaining quality of response. It does not appear that explicitly labeling each post helps the student in the argumentation process, and may actually inhibit the process.

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APPENDICES

Appendix A

Argumentation in an Online Mathematics Class

You are invited to participate in a study of argumentation with message constraints being conducted by Beth Wentworth, Assistant Professor of Mathematics, Chadron State College.

You have been selected for participation in this study because you are a participant of a professional Development Series in mathematics which uses an online component. The online component will involve critical thinking and interaction among the participants.

The purpose of this study is to extend the effects of message constraints and labels on collaborative argumentation in asynchronous mathematics online discussions.

If you decide to participate, you will be asked to do the following things: Participants will be placed in groups of ten, with five supporting the question and five opposing the question. Each member of the group will be assigned a constraint with or without labeling. The labels group will be also asked to label each of their messages. Discussions will take place within the small groups. The participants will complete four discussions.

Dependent variables will include the following:

- The number of each type of message posted, and of total messages.
- An event sequence analysis of what types of messages were most likely to follow others.
- Specific following of argument chains for arguments that extend beyond an initial post and response, to analyze depth of discussion.

There are no known risks for participation. Participants will engage in online discussions with their peers, and may learn about critical thinking and argumentation.

The potential benefits for the participant will be in knowing the type of questions to be asked in an online discussion format.

Participants are not compensated for participation in the study. The study is a separate optional part of the professional development series for which no extra compensation is offered.

All information will be kept confidential. In the data analysis phase, all names will be replaced with non-meaningful codes. (A, B, C, D) Under no circumstances will the participants' personal information be disclosed. At the conclusion of the study, all information will be properly destroyed.

Your participation in this study is voluntary. Your decision whether or not to participate will not affect your present or future relationship with Chadron State College. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time.

You should feel free to ask questions now or at any time during the study. If you have questions, you can contact Beth Wentworth at 308-432-6406. If you have questions about the right of research subjects, contact the Chair of the Chadron State College Institutional Review Board at 1-308-432-6203.

Consent Statement:

You are voluntarily making a decision whether or not to participate. Your signature indicates that, having read and understood the information provided above, you have decided to participate.

You will be given a copy of this consent form to keep.

________________________________ ____________________

Signature of Participant Date

________________________________ ____________________

Signature of Investigator Date

Appendix B

Discussion 1:

In a two-person game, player A rolls two ordinary dice with the faces of each die marked 1 through 6. Player B, however, uses number cubes with the faces of a red cube marked 1, 3, 4, 5, 6, 8 and the faces of a green cube marked 1, 2, 2, 3, 3, 4. If the player rolling the higher total wins, would you prefer to be player A, or player B?

Those who were told to support the topic would prefer to be player A.

Those who were told to oppose the topic would prefer to be player B.

No Label

A1F: (EXPLo)[12/1/08 1:34PM] I would prefer to be player B. The die with an eight on it would give an advantage.

> A2M: (CRITo)[12/3/08 9:50AM] What kind of an advantage would this be? Do you mean by advantage that the outcomes are somehow weighted? Is it more likely that the 8 will appear more than others? If that is your belief, then the 3 would give an advantage more than the 8.
>
> > A1F: (EXPLo)[12/4/08 1:26PM] You said, "a single 8 on player B's die is already greater than two die combinations that add up to 7 or less. This means that a single die beats 21of the 36 possible two dice combinations for player A." That could be a definite advantage for player B. How many times are we rolling? That could be a big factor.

This is in reply to a labeled post.

> A2M: (CRITo)[12/3/08 9:46AM] Although the distributions are the same, don't forget that a single 8 on player B's die is already greater than the two dice combinations that add up to 7 or less. This means that a single die beats 21 of the 36 possible two dice winning combinations from player A.
>
> > A4F: (EVIDs)[12/13/08 11:38PM] Even though the 8 is larger on the die, the second die has more smaller numbers that actually repeat so your sums will be smaller. On the second die there is not a 5 or 6 so your sum would not be as large as the roll of player A.

A4F: (EVIDs)[12/1/08 10:06PM] I would like to be player A. Player A has 2 ways to roll an 11 where player B only has 1 way. Player A can get an 11 with (5,6) and (6,5) and player B can only get an 11 with (3,8), this choice cannot be reversed so there is only 1 way to get it.

A1F: (EXPLo)[12/2/08 1:14PM] Player B has two 3's on one die. Player B could also role a 11 two ways.

A4F: (EVIDs)[12/13/08 11:37PM] I believe rolling a (3,8) and then another (3,8) is really only counted as one way. To have it count as two different rolls you must be able to roll the numbers in different positions. Player A has both the (3,5) and the (5.3).

A1F: (EXPLo)[1/5/09 1:18PM] When I look at the sample space I don't see what difference it makes that (3,8) and (3,8) use two different threes on the same die.

A2M: (CRITo) [12/3/08 7:23AM] Contextually, there are some other things to consider. We were asked to pick A OR B, not A AND B. There are some other things to look at before glancing at the probability distribution function and dismissing the idea of A or B.

This is a game. The one who rolls the higher value FIRST wins the game. That begs a geometric probability question, who will roll the higher value first. This is a game of not only totals but order as well.

A4F: (EVIDs)[12/13/08 11:45PM] Order does not have anything to do with this. We are looking at sums so it does not matter which die number you roll first. This question is a combination idea rather than permutation.

A2M: (CRITo)[12/29/08 11:56AM] Au contraire! If this were not a G A M E, I would agree with you; however, it is a game and the question was which player would you like to be based on the types of dice that you have. I agree that a probability distribution function will give you the same distribution; however, you must look at the geometric probability distribution function as to which will roll a higher number FIRST.

C3F: (EXPLs)[12/5/08 9:13PM] I would like to be Player A because both of A's dice use an equal amount of higher numbers.

C3F: (EXPLs)[1/1/09 8:33PM] Is it okay to want to be Player A because those dice are familiar to the player?

Label Group

A3F: (EVIDo-Label)[12/1/08 6:47PM] The sample space of both outcomes (player A and player B) show identical possibilities for outcomes. The sums both have equal chances of rolling a 2 or 12, which would be 1 out of 12. The probability of rolling a 3 or 11 for either player is 5 out of 36. Either player would have the probability of rolling a sum of 4 or 10 of 3 out of 36, or 1 out of 12. The probability of rolling the sum of 6 or 8 would be 5 out of 36 for either player and the probability of rolling a 7 for each player would be 6 out of 36 or 1 out of 6.

A3F: (EVIDo – Label)[12/2/08 4:53PM] You are right, there is only one way to get an 11. However, you get a mound-shaped distribution. And, in that the outcomes in the middle of the range are the most likely to occur, where the outcomes at the extremes are the least likely to occur.

B1F:(EXPLo-Label) [12/4/08 7:47AM]

I would rather be player B. When given the total outcomes they are the same for both players. I would rather be player B because I have an 8 on my die and that would allow me a 1/6 chance of rolling a combination that had that 8 and would increase my score.file:///Users/tinathompson/Desktop/Player%20A.xls

Player A	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10
5	6	7	8	9	10	11
6	7	8	9	10	11	12

Player A	
2	1
3	2
4	3
5	4
6	5
7	6
8	5
9	4
10	3
11	2

12	1

Player B	1	2	2	3	3	4
1	2	3	3	4	4	5
3	4	5	5	6	6	7
4	5	6	6	7	7	8
5	6	7	7	8	8	9
6	7	8	8	9	9	10
8	9	10	10	11	11	12

Player B	
2	1
3	2
4	3
5	4
6	5
7	6
8	5
9	4
10	3
11	2
12	1

B2F: (EVIDs-Label) Support: [1/2/09 11:03AM]

In my simulation of 30 rolls, I found that Player A would win 16 of the 30 times, Player B 11 of the 30, and there were 3 ties. Total of all 30 rolls for each Player also had Player

A winning. A total on 30 rolls : 222, B total on 30 rolls: 210.
Based on 30 rolls in my first experiment, Player A would indeed win.

I found a dice simulation website that allowed me to create my own six-sided die with sides of 1, 2, 2b, 3, 3b, and 4 and sides of 1,3,4,5,6,8 to simulate Player B dice. It also allowed multiple windows, so I could roll both rolls on the screen and record.
http://www.bgfl.org/bgfl/custom/resources_ftp/client_ftp/ks1/maths/dice/index.htm

Attached is the .xls spreadsheet of my results.
(spreadsheet omitted)

B3F: (ARGo- Label)[1/3/09 8:43PM]: I would prefer to be player B. There are larger numbers on my dice.

[1/3/09 9:28PM]The possible totals for both players are identical, but player B has a 1/3 chance of getting a 6 or an 8 on his first toss. If the second toss for both players is a 1, 2, 3, or 4 and player B has a 6 or 8 on the first toss his total will be greater than or equal to Player A's total.

C1F: (EXPLo-Label)[12/1/08 2:40PM] I feel the probability of obtaining a higher number on the die would occur because of the combinations of numbers for player b. One side of the die with 8, increases the probability statistics.

C2F: (ARGo-Label)[12/5/08 9:33AM] We would not want to be Player B because when even though the red die had a number than 6 the green die had all numbers smaller 5. When the numbers are added the game is fair but if the sample space was never written out then you wouldn't know.

This is a reply to a NL post

> C2F: (ARGo-Label)[12/11/08 9:23AM] I agree that at first player A looks more fair but when the sample space is done then you see that player B has the same sample space as player A.

C4F: (CRITs- Label)[12/20/08 1:43PM] Player B appears to have the advantage, however, only one of the dice has the large numbers, the other has small numbers. If you write out the sample space for each set of dice, the probability of getting each sum is the same.

> C5M: (EVIDo- Label)[1/5/09 8:50PM] I listed out the outcomes but multiplied, oops. I need to go back and reply to my own post!

C4F: (CTIRs- Label)[12/20/08 1:54PM] Some questions have arisen with the fact that one of Player B's dice has two 3's. So, do you count 3,1 and 3,1 as two separate combinations or one?

C5M: (EVIDo- Label)[1/5/09 8:48PM] Good question, I listed it as one possibility.

C5M: (EVIDo- Label)[1/5/09 8:48PM] After reading about the two different dice scenarios, I thought to myself that the dice that were not numbered 1-6 would be the better option. I am not sure why though. Then I sat down and listed the possibilities and then listed the outcomes from low to high, side by side and saw that the normal dice would be the better choice.

[1/5/09 8:54PM] After re-reading the game and redoing all the possibilities, both sets of dice give the same samples. Interesting

Appendix C

Discussion 2: Suppose that you are the chief of maintenance for a large metropolitan hospital. You are trying to decide from what company to buy your next 5-year supply of light bulbs. Would you look to the company whose light bulbs have the greatest mean or the greatest median life? Explain your reasoning.

Those in support will argue for the greatest mean life.

Those in opposition will argue for the greatest median life.

No Label Group

A4F: (EVIDs)[12/13/08 11:523PM] You must purchase the lightbulbs with the greatest mean life since it would be the average life of all the bulbs. You want all your bulbs to have a long life so the mean gives all of them to you.

> A2M: (CRITo)[12/29/09 11:52AM] The problem with using the mean as a litmus to purchase a commodity such as light bulbs is that you are buying a lightbulb based on what the manufacturer states is "an average." Here are the pitfalls: 1) a few bulbs with really long lives can "average out" several bulbs with comparatively brief lives; 2) The average does not describe how the lives of the bulbs are dispersed around the mean--that is, are the bulb lives clumped near the mean, or are they all over the place making bulb replacement a guessing game; 3) and, how likely is it that if you bought 1,000 bulbs that at most 500 of them would meet the average?
>
> > A4F: (EVIDs)[1/2/09 9:09PM] I still believe that using the mean would be the best choice for making your decision. In Michael's example, in theory 500 of the 1000 bulbs would meet the length of life. That is what we want. Half of the bulbs would last longer than this time and half would not. The mean is the magic length of time that we would want to compare in the companies.
> >
> > > A1F: (EXPLo)[1/5/09 1:26PM] Were we told that this was a normal distribution? The data could be skewed. There are not necessarily a neat half above the mean and half below.

This is in response to a Labeled post.

> A2M: (CRITo)[12/29/08 11:44AM] Remember that your job is to purchase the lightbulbs, not question the fact that your data may be incomplete. In the business world (in any world for that matter) knowing where or how the information was gathered may never be defined. The "data" may, and often is not, be complete. Finally data analysis may not even come close to "making sense of the situation." For example, we have incredible amounts of data on oil pricing; however, making sense of it is pointless.

A5F: (ARGs)[12/30/08 3:18PM] You would want to purchase the lightbulbs with the longest mean life. This would represent the longest average life of all the bulbs and give you the best picture of life length.

A1F: (EXPLo)[1/5/09 1:31PM] The median would be a better choice to watch for what most bulbs do. Someone else questioned how the data was gathered. How many bulbs were studied. Perhaps one bulb was in an ideal situation and lasted for 15 years. Most bulbs lasted a year or two. A few high numbers can drag the mean up, even if they are outliers.

C3F: (EXPLs)[12/15/08 11:03PM] I suppose that the hospital will buy a lot of light bulbs. So any outliers won't have a drastic effect on the mean like they might for a small number of bulbs. Therefore mean will be more representative of the life of the typical bulb.

In response to a Labeled post.

> C3F: (EXPLs)[1/13/09 6:35PM] I agree that mean can be affected by extreme high or low numbers and that an outlier would greatly affect the mean of a small group of numbers, but given that a hospital must order a large number of light bulbs, the number and kind of outliers would be negligible.

Label Group

A3F: (EVIDo-Label[12/14/08 4:04PM]) In my reading data analysis is described as a process that makes sense of a situation. This leads me to wonder the purpose the light bulbs fulfill, and how was the information gathered?

B2F: (EVIDs- Label)[1/3/09 1:00PM] Found online:
Question? Is this an accurate use of 'median'?

How long should light bulbs last?
Light bulb manufacturers, including GE, adhere to a standard industry rating for light bulb life called "rated life." Check your light bulb package to see the rated hours of life for your particular bulb.

The rated life is a measure of the median time in hours that it takes for a light bulb to burn out. This is the point in laboratory testing at which half the test bulbs have burned out and half the test bulbs are still burning.

A 60-watt incandescent bulb may have a rated life of 1,000 hours. However, not all bulbs of this type will last exactly that long. That rated life is the median — the point in lab testing when 50% of the test samples have burned out and 50% are still burning.

http://www.gelighting.com/na/home_lighting/ask_us/faq_defective.htm

In response to a NL post.

C2F: (ARGo-Label)[12/19/08 11:08AM] The mean would be greatly affected by bulbs that arrived broken and were unable to be used. However if you looked at the median the broken bulbs would have no impact.

C5M: (EVIDo- Label)[1/5/09 8:58PM] I think the greater number of bulbs will have a larger effect then a smaller number.

C2F: (ARG0-Label)[12/19/08 11:06AM] It would be better to look at the median because it would be closer to the middle and wouldn't be affected if there were outliers such as light bulbs that may be dropped and broken before ever being used.

C5M: (EVIDo- Label)[1/5/09 8:56PM] true

B3F: (ARGo-Label)[1/3/09 8:56PM] I would buy from the company with the greatest median. The median would not be affected by outliers such as bulbs with broken fillaments. I would expect that the working bulbs (most of them) would last about the same amount of time, so the median would be closer to the upper limit than the lower limit.

C5M: (EVID0- Label)[1/5/09 8:56PM] true

C5M: (EVIDo- Label)[1/5/09 8:56PM]Mean can be affected by extreme low or high numbers. Median is a better way to look at the middle. The median is not affected by such extreme numbers since you are not using a sum but rather the number of pieces of data to find the middle.

C2F: (ARGo-Label)[1/7/09 10:09AM] Knowing this information, why would a company ever use mean to report their statistics?

Appendix D

Discussion 3: One student puts either a black or white marble into a sack, without the second student looking. The second student puts a white marble in the sack, shakes the sack, and then draws out one marble. Is the information helpful to guessing the color of the marble initially placed in the sack? (This is a problem posed by Lewis Carroll of *Alice in Wonderland* fame in his book *Pillow Problems*.)

A2M: (CRITo-not labeled)[1/27/08 12:48PM] If you do not know what color marble is in the sack, then you have two sample spaces for extraction: ww or wb, since **you** will know that one of the marbles is white (the one you dropped in). If the sample space is "ww," then P(w) = 1; but, if the sample space is "wb," the P(w) = 1/2. If you know what color marble your friend drops in the bag, then you will know that you will draw out a white [P(w) = 1]. If you know the first marble was black, then P(w) = 1/2. Therefore, it doesn't make any difference if you know or not.

> A4F: (EVIDs-no label)[1/29/09 7:52PM] It does make a difference if you know what color marble was placed in the sack by one person. Since one person placed a white marble in sack, when a white is drawn, you have not really learned anything. It could have been the unknown marble or the white that you knew was placed in the sack. In this case, you would still have a probability of 1/2 on the color of the unknown marble. If a black is drawn on the first draw, you know with 100% certainty that the unknown marble was black. Having more knowledge is helpful here.

In response to a Labeled post.

> A4F: (EVIDs)[1/14/09 8:20PM] Karen has some good points in her argument. The evidence that if a white marble is pulled from the sack, you have not gained any information about the first marble. You do not know if the white marble drawn is from the first or second person. If a black marble is drawn, you know that it must have been the first marble since the second person placed a white marble in the sack. With the white marble drawn, your conclusion is not helped. 50% is the probability in guessing that first marble.

C3F: (EXPLs-no label)[2/8/09 5:49PM] It certainly would be helpful if you could repeat the scenario several times.

Label Group:

C2F: (ARGo-Label)[1/13/09 9:13AM] The information is not helpful in drawing a definite conclusion as to the color of the first marble. Since there are only 2 choices as to the color of the marble then there is a 50% chance to guess the correct color of the first marble. The only way that the percentage of guessing correct would increase is if you know that a black marble is drawn out of the bag. Then you would know that the first marble is black with 100% certainty. If a white marble was drawn then it wouldn't change the percentage of guessing correct.

C5M: (EVIDo Label)[21/09 8:36PM] The person drawing out from the sack does know all possibilities.

C5M: (EVIDo-Label) The person drawing out from the sack does know all possibilities.

Appendix E

Discussion 4: Two sociologists mailed out questionnaires to 20,000 high school biology teachers. On the basis of the 200 responses they received, they claimed that fully 72% of high school biology teachers in the United States believe the biblical account of creation. Is their claim justified by this survey? Those in support say they are justified, those opposed say they are not justified.

No Label Group

A4F: (EVIDs-no label)[1/29/09 7:47PM] The two sociologists are justified in their claim. Since they did receive 200 surveys back, they can use the results of this mailing to make a claim. 72% of the 200 surveyed is 144 that said that they believe in the biblical account of creation. That seems like plenty to me.

A1F: (EXPLo)[2/18/09 4:08PM] I have to question the survey's technique. Were there other questions on the survey? Who was most likely to respond? I am unlikely to mail back a survey that covers topics I don't care about or that is to lengthy.

A2M: (CRIT0)[4/2/09 2:38PM] Surveys like these generally elicit responses from groups that support the idea of the survey, especially if the group even remotely believes that the survey may bring about change in favor of their philosophy/beliefs.

The survey would/might have been more reliable if it couched all theories and data was collected on all theories, not just one.

In response to a Labeled post.

> A4F: (EVIDs-no label)[2/4/09 10:17PM] I believe they actually only received 1% back on their survey, but that is still good. Any claim on 200 responses is a good number to draw a conclusion.

C3F: (EXPLs-no label)[2/8/09 5:44PM] Based on the returns, their conclusion is justified. A lot of conclusions are made on less response.

Label Group

C5M: (EVIDo-Label)[2/1/09 8:40PM] I know that you received 10% back which I believe is a good return rate, but I would like to know your origianlly audience, was it all public, or a mix and what age group, etc.

C2F: (ARGo-Label)[2/16/09 9:33AM] I disagree that 1% is a good return rate.

In response to a No Label post.

C2F: (ARGo-Label)[2/16/09 9:32AM] With only 1% response rate it would not be justified. Maybe only those who believe in the bible responded.

C2F: (ARGo-Label)[2/16/09 9:30AM] It is not justified because they only had 200 responses out of 20,000. You cannot judge a total populations results with only a 1% response rate. This survey does not show justified results.

Appendix F

Discussion 5: According to Garrison Keillor, all the children in Lake Wobegon are above average. Is sthis assertion just a joke, or is there a sense in which it could be true? Explain.

No Label Group

A1F: (EXPLo)[2/18/09 4:13PM] If we are comparing the children of the community to the population of the community the statement doesn't make sense. They would have to define the average for their community. If we compare their community to the nation as a whole it could be true. If you listen to the stories that follow this statement I would very seriously doubt it.

C3F: (EXPLs- no Label)[2/15/09 11:08PM] The town may be one that does a good job educating all of its children, so even the least educated has a good education. We could also look say that everybody has a talent and is above average in something.

In response to a Labeled reply.

> A4F: (EVIDs)[2/16/09 9:19PM] To be above average would be an easy claim to make. You would be able to make everyone above average in something. You could find a subset somewhere in the world that is lower than that person at Lake Wobegon so they could be considered above average. This claim would be easy to make since EVERYONE could be above average in something.

In response to a Labeled post.

A4F: (EVIDs)[2/16/09 9:20PM] The idea that there are no parameters is what makes the claim possible. You could find something that everyone would be above average in. The claim does not have to have the same criteria for everyone.

Label Group

In response to a No Label post.

C2F: (ARGo-Label)2/16/09 9:39AM] The basis for an above average rating needs to be on one category and not one above average over multiple categories. This would be an inappropriate claim to fame.

C2F: (ARGo-Label)[2/16/09 9:37AM] I believe that this is a joke because there is no testing done to prove that they are above average. What are they above average in? Are they above average intelligence, height, chess players, dancers, or weight? There needs to be more information and a test run to verify the information.