Teachers' Perceptions of Discourse Usage in Elementary and Middle Grades Mathematics

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ABSTRACT

This dissertation is motivated by the research question “do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of univocal discourse usage, dialogic discourse usage, and general discourse usage”? This research is a survey design with foundations from Truxaw, Gorgievski, and DeFranco's (2008) instrument on classroom discourse usage. The goal of this study was to assess group differences in teachers' perceptions of univocal, dialogic, and general discourse, as well as differences due to the level of experience and education were explored. There were two statistically significant main effects for teaching experience as well as one statistically significant effect for grade band. For teaching experience and the dialogic discourse score, teachers with 11 or more years of experience had a mean dialogic discourse score (M = 35.85, SD = 5.30) that was significantly higher on average than teachers with 0 to 10 years of experience (M = 34.14, SD = 5.93). The mean of the elementary group (M = 34.78, SD = 5.65) was significantly lower than the mean of the middle grade level band group (M = 38.00, SD = 4.15). For teaching experience and the general discourse score, teachers with 11 or more years of experience had a mean general discourse score (M = 12.46, SD = 1.76) that was higher on average than teachers with 0 to 10 years of teaching experience (M = 11.83, SD = 2.05). The results and future research were discussed, and the findings support a need for further change centered on dialogic discourse.

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DEDICATION

To my parents, Marshall and Linda Tuck, thank you for instilling in me that education is a lifelong journey. Thank you for continuous, late night, edits. I am forever indebted.

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Chapter I

INTRODUCTION

The NCTM's (2000) *Principles and Standards for School Mathematics* claim it is beneficial to have students engaged in rich discussions, not merely explaining steps they took to solve a problem (NCTM, 2000a; NCTM, 2000b; NCTM, 2014). Mathematics classrooms need less monologue and more engaging dialogue. Current classrooms have an overabundance of univocal discourse, and a need for dialogic discourse. Discourse enables students and teachers to reflect on their own understanding, while making sense of others' thinking. This supports student achievement and higher order thinking skills, which are a critical requirement of the Common Core State Standards Initiative. The United States is in dire need of workers who can persevere and attend to precision. The National Council of Teachers of Mathematics (NCTM) defines classroom discourse as the mathematical communication that develops in a classroom. Effective discourse "happens when students articulate their own ideas and seriously consider their peers' mathematical perspectives as a way to construct mathematical understandings" (NCTM, 2010a, p. 1). Teaching with an emphasis on discourse and argumentation is a powerful tool, which can transfer to many subject areas including mathematics (NCTM, 2000b; NCTM, 2014; Rumsey & Langrall, 2016).

The NCTM (2000b) outlines six principles for educational decision makers within school mathematics, which include equity, curriculum, teaching, learning, assessment, and technology. The NCTM suggests using these principles to guide decisions for school mathematics, and they highlight the basic characteristics of high quality mathematical instructional programs. The teaching principle, according to the NCTM, presents an additional set of six standards for teaching mathematics. The additional six standards within the teaching principle address "worthwhile mathematical tasks; the teacher's role in discourse; the student's role in discourse; tools for enhancing discourse; the learning environment; and the analysis of teaching and learning" (NCTM, 2000b, p. 17). Children cannot solve problems without understanding and using the mathematical content. Discourse is a highly effective way for students to generate an understanding of such content during problem-solving tasks.

Statement of the Problem

Effective Mathematics teaching calls for a deep commitment to the development of students' understanding of mathematics (NCTM, 2000b; NCTM, 2014). As Galileo once declared, "you cannot teach a man anything, you can only help him find it within himself" (Malone, 2003, p. 97). The problem is that mathematics classrooms focus on the content standards with slight emphasis on the process standards (Boaler, 2015; McGatha & Bay-Williams, 2013). The process standards, according to the NCTM (2000b), include problem-solving, reasoning and proof, communication, connections, and representation. Communication in the mathematics classroom is vital to students sharing their understanding of concepts and procedures. Students engage in extraordinary levels of communication every day (Barnes & Toncheff, 2016; Steele, 1995). In most traditional mathematics classes, the prevailing discourse is univocal (Truxaw & DeFranco, 2007), therefore the teacher's questioning and feedback are used to convey information to students, leading towards the teacher's point of view.

Communication can have great education impact. Hattie et al. (2016) claim discourse and classroom communication have an effect size of .82. Hattie et al. (2016) use a Cohen's d to measure effect size. Each Cohen's d effect size measure is calculated by taking the difference between two means and dividing that by a standard deviation for the data. An effect size of .4 is typical, and anything above encourages greater impact on student achievement. This means classroom discussion allows students to improve communication skills by voicing their opinions and thoughts (Hattie et al., 2016). Discourse and classroom dialogue can have a positive impact on student learning. In fact, discourse is found within what Hattie refers to as the Zone of Desired Effects. With an effect-size this large, discourse results in two years of learning gains for a year of schooling. Teachers "would be wise to focus their energy on building classroom discourse rather than attempting to teach test-taking" (Hattie et al., 2016, p. 41). According to research by Hattie et al. (2016), direct instruction had an effect size of 0.59, while classroom communication had an effect size of 0.82. The issue should not be direct versus dialogic but rather "the right approach at the right time to ensure learning" (Hattie et al., 2016, p. 62).

The Gap in the Current Literature

There is a gap in the existing literature because current literature encompasses many case studies of exceptional teachers, but there is little quantitative data regarding teacher perceptions for an entire district. This project adds to current research in mathematics education by contributing a quantitative view of teachers' perceptions of discourse practices in a school district in southeastern Georgia**.** Mathematics education continues to generate new knowledge, tools, and ways of doing and communicating mathematics (NCTM, 2000a) and this research will support the ongoing evolution in mathematics education.

Purpose of the Study

The NCTM recommends communication and mathematical discourse since they are essential to building mathematical understanding (NCTM, 2014). The goal of this study will be to assess group differences in teachers' perceptions of univocal, dialogic, and general discourse as this is constant with NCTM's recommendation regarding communication in mathematics classrooms. In addition, differences due to the level of experience and education will be explored. Results of this research can provide a helpful step toward enhancing teaching practices for mathematics classrooms.

Original Contribution

The original contribution this study will make is an understanding of current practices and perceptions of the use of discourse in kindergarten through eighth-grade mathematics classrooms in southeastern Georgia. Much of the current literature focuses on case studies of single or multiple teachers (Bennett, 2010; Blanke, 2009; Rolle, 2008). Several studies offer a case study approach of one classroom and the discourse patterns within. One such case study focuses on classroom structure for teachers implementing discourse to support student learning. Other studies focus on communication in higher-level coursework and some of the current research focuses on writing as discourse for learning mathematics. Current research highlights positive aspects of appropriate discourse in mathematics classrooms.

The Significance of the Study

Advancing Theory

This research will offer teachers an opportunity to understand current practices and encourage positive social change. One of the most powerful ways to raise student achievement is through professional learning and teachers understanding effective instructional practices (DuFour & Mattos, 2013). Intensive professional development for teachers has the potential to lead to increases in student achievement, the goal of all educators (Garet et al., 2016). Social interaction "provides us with the opportunity to use others as resources, to share our ideas with others, and to participate in the joint construction of knowledge" (Smith & Stein, 2011, p. 1).

Research supports that mathematics achievement is associated with classroom communication and discourse (Hufferd-Ackles, Fuson, & Sherin, 2004; Whitenack & Yackel, 2002). However, researchers revealed that teachers in the United States continue to state information, rather than allow students to develop ideas through discourse (O'Brian, 1999). Mathematics plays an important role throughout the lives of children, and the findings from this study can lead to positive social change by influencing teachers' perceptions of their current discourse practices.

As stated by the vision of the NCTM (2000b), there is a need for continued improvement of mathematics education. Findings may also offer new insights or approaches to research. McGatha and Bay-Williams (2013) advocate seven shifts to occur in mathematics classrooms that would be beneficial. The seven shifts according to McGatha and Bay-Williams (2013) include:

> Shift 1: From same instruction toward differentiated instruction. Shift 2: From students working individually toward the community of learners. Shift 3: From mathematical authority coming from the teacher or textbook toward mathematical authority coming from sound student reasoning. Shift 4: From teacher demonstrating "how to" toward teacher communicating expectations for learning. Shift 5: From content taught in isolation toward content connected to prior knowledge. Shift 6: From a focus on correct answer toward a focus on explanation and understanding. Shift 7: From mathematics made easy for students toward engaging students in the productive struggle. (p. 167)

When any or a combination of these shifts occur, the teacher and the students benefit. The teachers and students become co-constructors of knowledge and the students are more motivated which increases student achievement.

Shift 1 for classroom practices focuses on the same learning outcome for all but the differentiated instruction to achieve the same learning outcome (McGatha & Bay-Williams, 2013). Shift 2 focuses on a community in which students judge the reasonableness of their strategies and solutions. Shift 3 focuses on the accuracy of a solution being based on reasoning about the strategy to the solution. Shift 4 focuses on the teacher sharing learning goals and expectations. Shift 5 has a focus on making mathematical connections to prior knowledge. Shift 6 takes the focus and places the discussion to focus on student explanations and why an answer is, or is not, correct. Shift 7 focuses on perseverance and multiple attempts to a teacher posed task.

One shift this research may encourage is the change from a focus on correct answers to a focus on discussions (McGatha & Bay-Williams, 2013). We must evolve from students explaining steps they completed to solve a (known) procedure and toward rich discussions that focus on how, why, and when a certain approach might work (McGatha & Bay-Williams, 2013). Future mathematics classrooms will focus on student explanation addressing why the answer is or is not correct (McGatha & Bay-Williams, 2013). Knowing mathematics is empowering and satisfying (NCTM, 2000b). Mathematics underpins everyday life. I interpreted the findings to see if specific subgroups vary in their perceptions of discourse types.

Advances in Practice

Teacher leaders need this research to differentiate professional development based on teacher perceptions of their use of discourse types. Teachers' perceptions and beliefs play a significant role in how they experience learning and their perceptions influence strongly what they will or will not do in their classrooms (Carnegie, 2014). Educators can use the results to reflect upon and improve their own practice as mathematics teachers. Teachers shape their thoughts by their background knowledge and life experiences (Yero, 2016). When teachers do not have a strong foundation in current pedagogy, students are negatively affected (Hill, Rowan, & Ball, 2005; Polly et al., 2015). This research supports professional practice by guiding professional development needs and decisions as discovered in the results. The results inform teacher practice and implementation of teacher professional development that focuses on discourse in elementary and middle grades mathematics instruction. Teachers with little information about the different discourse may naturally form perceptions, some of which may be negative towards including discourse in their classroom. This can lead to misperceptions of information.

The United States needs highly trained personnel who can grapple with complex problems (Battista, 1994). Core competencies are no longer yielding high paying jobs nor do basic skills allow for an acceptable standard of living. Compelling students to have mathematical discussions about content is one of the best ways to engage in formative assessment (Chapin, O'Connor, & Anderson, 2009). Effective teaching requires repeatedly seeking improvement in mathematical pedagogy (NCTM, 2000b; NCTM, 2014). According to the vision for school mathematics "orally and in writing, students communicate their ideas and results effectively. They value mathematics and engage actively in learning it" (NCTM, 2000b, p. 3). Because NCTM recommends communication and notes it as important to help students build meaning about mathematics, this project enhances teachers' practice by driving professional development opportunities. Many researchers support the importance of mathematics teachers allowing for student discussions and leading discussions themselves (Gonzalez & DeJarnette, 2013; Hufferd-Ackles, Fuson, & Sherin, 2004; Otten, Cirillo, & Herbel-Eisenmann, 2015; Otten, Engledowl, & Spain, 2015).

Background of the Study

Researchers of national and international mathematics assessments suggest a need for improvement in math achievement among students within the United States (Garet et al., 2016). The 2011 Trends in International Mathematics and Science Study (TIMSS) results justify the importance of this study (NCES, 2015). The study is an international longitudinal research project to measure trends in math and science, which suggests other countries in mathematics constantly outscore the United States. In the 2011 study, the following systems outperformed the United States average in fourth and eighth grade: Chinese Taipei, Flemish Belgium, Hong Kong-China, Indiana, Japan, Korea, Massachusetts, Minnesota, North Carolina, Northern Ireland, Quebec-Canada, and Russian Federation.

In the NCES 2015 study, over 60 countries took part. According to the National Center for Education Statistics (NCES) on the National Assessment of Educational Progress (NAEP), the United States is below the following countries in fourth and eighth-grade mathematics: Hong Kong, Russian Federation, Finland, Singapore, and Northern Ireland. The NAEP is another longitudinal nationally represented assessment of American students' achievement (The Nation's Report Card, 2016). Approximately 13,200 American students took the NAEP mathematics assessment in 2015. Unfortunately, the 2015 average United States mathematics score was lower than the 2013 mathematics score for both fourth and eighth-grade students (The Nation's Report Card, 2016). For the 2015 assessment, 40% of fourth graders and 33% of eighth graders in the United States performed at or above the proficient level in mathematics NAEP.

Loucks-Horsley (2010) asked if students will meet the learning goals we have established, what new knowledge, practices, and beliefs do teachers need, and how will they gain them? Unfortunately, the teachers teaching mathematics often know limited mathematical content. Researchers have linked teacher content knowledge in mathematics and science with higher student performance (Loucks-Horsley, 2010). To best help students learn, students rely on teachers to be current on content. Only twenty-five percent of twelfth-grade students performed at or above the proficient level (The

Nation's Report Card, 2016). Georgia's fourth graders placed thirty-eighth with a score of 236, while Georgia's eighth-graders placed thirty-fourth with a score of 279 (The Nation's Report Card, 2016). The average score for fourth and eighth graders were 240 and 281 respectively (The Nation's Report Card, 2016). It must also be kept in mind that test scores do not always predict innovation.

Shifts in classroom practice should include focusing on explanations and understanding as opposed to an emphasis on the correct answer (McGatha & Bay-Williams, 2013; NCTM, 2014). One such shift involving discourse includes a change from the teacher showing how to correctly compute a math problem to the teacher communicating the expectations for learning (McGatha & Bay-Williams, 2013) and supporting students as they theorize potential pathways toward a solution (Kimani, Olanoff, & Masingila, 2016). In this current model of best practices, the teacher becomes the facilitator and allows students to share their thinking (McGatha & Bay-Williams, 2013).

Discourse, in its most basic form, as defined by the NCTM is the mathematical communication that occurs in the classroom (NCTM, 2010a) and is effective when students can articulate their own thinking and consider peers' perspectives. The goal of embedding classroom discourse in a mathematics classroom is conceptual understanding. When promoting discourse in a mathematics classroom, the teacher plays a special role in facilitating and steering discourse (Springer & Dick, 2006). “The decisions a teacher makes about what to say or do next during a class period may follow a carefully laid out plan” (Springer & Dick, 2006, p. 106). Rarely does classroom discourse play out as the teacher envisions. Teachers can use scripted moves (planned out in advance) to set the context of the example, teachers can also use provisional moves which are anticipated and changed on cues from the students. Additionally, teachers can use improvisational moves which are made up in response to unanticipated developments in the classroom discourse (Springer & Dick, 2006).

Such discourse moves can be influences by the intentional type of discourse the teacher is choosing. Univocal discourse is one-way communication in which the listeners should all receive the same message. Dialogic discourse is two-way communication, which varies from conversation to conversation. Dialogic discourse is used to construct new meaning whereas univocal discourse is used to convey information. O'Connor and Michaels (2007) note dialogic discourse “connotes social relationships of equal status, intellectual openness, and possibilities for critique and creative thought” (p. 477). General discourse can be understood as evaluative, generic discussion, rather than discussion intended to create understanding or construct new meaning (Otten, Engledowl, & Spain, 2015; Truxaw, Gorgievski, & DeFranco, 2008).

Conceptual Framework for the Study / Theoretical Foundation

A well-developed conception of mathematics teaching is critical for teachers to understand their role as educators (Simon, 1995). Teachers need access to relevant and current research of mathematical thinking, curriculum materials, and ongoing professional development to become a successful mathematics teacher. Constructivism (often called social constructivism) is one worldview grounded in understanding, multiple participant meanings, social and historical construction, and theory generation (Creswell, 2014).

It is not surprising that social constructivism is on the forefront of mathematics education. Social constructivism allows students to create a path to understanding. Social constructivism challenges the view that the teachers are the givers of knowledge (Brickhard, 1997). Through social constructivism, students can explore and develop their understanding of topics. Social constructivism addresses how students learn and what teachers can do to facilitate students' understanding and suggests that mathematical understanding results from people forming their models in response to questions and ideas and not simply taking information from others (Simon, 1995; Stiff, 2001). Social constructivism challenges the procedures by which individual students construct their knowledge (Brickhard, 1997).

Constructivist mathematics classes have students talking with one another, and teachers questioning students' understanding of mathematical relationships, concepts, and processes. Some critics believe this is not an appropriate way for mathematics to be taught and learned. The critics of reform mathematics agree that teachers arrange students in rows and that teacher lectures should dominate instruction (Stiff, 2001). "The constructivist teacher, by offering appropriate tasks and opportunities for dialogue, guides the focus of students' attention, thus unobtrusively directing their learning" (Clements & Battista, 2009, p. 7).

Constructivist teachers pose problems and encourage students to think deeply about their solutions. These teachers promote and encourage students to make connections to previous learning in mathematics and other content disciplines. Constructivist teachers ask students to explain the mathematics (Stiff, 2001). This type of teacher belief directly aligns with standards-based mathematics classrooms.

Constructivism addresses how students learn and what the teacher can do to facilitate understanding. Constructivist philosophies focus on what students can do to integrate new knowledge with existing knowledge to create a deeper understanding of the mathematics (Stiff, 2001).

Research Questions

Teaching experience, the highest level of education completed by the participants, and grade of teaching will be the independent variables for this study. The dependent variables will be the total score for the rating scale items for univocal discourse, the total score for the rating scale items for dialogic discourse, and the total score for the rating scale items for general discourse. The dependent variables are continuous on an interval measurement scale from 3 to 15 (general discourse), 6 to 30 (univocal discourse), and 9 to 45 (dialogic discourse). Since the total score is used, participants will each have a univocal discourse score ranging from 6 to 30 points, a general discourse score from 3 to 15 points, and a dialogic discourse score ranging from 9 to 45 points.

(1) Do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of univocal discourse usage?

(2) Do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of dialogic discourse usage?

(3) Do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of general discourse usage?

Definition of Terms

Univocal Discourse: Univocal discourse is communication characterized by meaning conveyed in one direction from one person to another (Knuth & Peressini, 2001). In univocal discourse, everyone receives the same message (Knuth & Peressini, 2001). Univocal discourse transmits information directly with little chance of misinterpretation (Knuth & Peressini, 2001). Teachers can view univocal discourse as a lecture where there is only one speaker and everyone else is a listener with interruptions to the speaker's delivery being prohibited or discouraged. Univocal discourse in a classroom can lead to the dialogic discourse.

Dialogic Discourse: In contrast to univocal discourse, dialogic discourse allows students to have two-way communication and interactions. The teacher does not always send and receive the same message with dialogic discourse and this allows the teacher to understand what students are thinking and enable students to generate new meanings through the process of interacting. The dialogic discourse has meaning that is negotiable and uses spoken words as thinking devices to generate new meanings.

General Discourse: General discourse as a reflection in the survey questions refers to discourse and communication based on teacher beliefs. These items can also be considered half dialogic and half "other" (univocal and general). The potential for varied interpretations of "verbal assessment by the respondents made the general discourse category seem a better fit than either dialogic or univocal" (Truxaw et al., 2008, p. 63).

Educational Level: One of the independent variables for this research study was educational level. The categories used for education level are Associate's degree, Bachelor's degree (T-4), Master's degree (T-5), and Sixth year (T-6) and above. These levels were chosen because they mirror the teaching certificate type offered by the Georgia Professional Standards Commission (Georgia Professional Standards Commission, 2013). These same levels of teacher certification are a reflection by the

Georgia Department of Education in their salary schedule. Level 4 is equivalent to a bachelor's degree, or the commissions determined degree equivalent. Level 5 is the completion of a master's degree or the commissions determined degree equivalent. Level 6 is completion of an Education Specialist's Degree or the commission's determined degree equivalent or completion of 36 semester hours of coursework required for a level seven doctoral degree. Level 7 is the completion of a Doctor of Philosophy or a Doctor of Education program or the commissions determined degree equivalent.

Experience Level: The second independent variable I used is the years of experience a teacher has had. This variable was categorized from 0-5 years, 6-10 years, 11-15 years, and 15+ years. This research added to the current connection between a teacher's experience level in years and their teaching quality.

The National Council of Teachers of Mathematics: The NCTM, founded in 1920, is the largest mathematics education organization. The NCTM has over 80,000 members throughout the United States and Canada. The NCTM is the public voice and global leader in mathematics education.

Standards for Mathematical Practice (SMP): The eight Standards for Mathematical Practice are a guide for good mathematics instruction with a focus on what it means to be mathematically proficient. The eight Standards for Mathematical Practice are: (a) Make sense of problems and persevere in solving them, (b) Reason abstractly and quantitatively, (c) Construct viable arguments and critique the reasoning of others, (d) Model with mathematics, (e) Use appropriate tools strategically, (f) Attend to precision, (g) Look for and make use of structure, and (h) Look for and express regularity in repeated reasoning (NCTM, 2014). These standards describe ways in which students should engage with mathematics as they grow in mathematical maturity and expertise throughout their kindergarten to twelfth-grade education. The Standards for Mathematical Practice are the heart and soul of mathematics. These standards are the overarching behaviors of a mathematician. If students are to construct viable arguments and critique the reasoning of others, “Students need guidance in building and weighing arguments with warranted evidence, which requires that they clearly explicate their reasoning so that others can understand and build upon or critique their ideas” (O'Connor & Michaels, 2007, p. 284).

Reform-Mathematics or Reform-Based Mathematics: Reform mathematics is a suggested approach to teaching that differs from the sit-and-get model which was used until the NCTM published its call for changes in mathematics education in 1989 (Boaler, 2002). Such changes began with the NCTM document titled Curriculum and Evaluation Standards for School Mathematics, which was published in 1989. Reform mathematics pertain to deemphasizing algorithms and focusing on discovering knowledge and conceptual understanding (Boaler, 2002).

Standards-Based Mathematics Classroom: A standards-based classroom, characterized by cooperative teaching and learning, allows students to take ownership and accountability for their learning outcomes (NCTM, 2000b; Stiff, 2001). Educators tie learning outcomes to the content standards, and teachers expect all students to meet proficiency. The environment for a standards-based classroom allows students adequate time, materials, and structure to learn. Students achieve equity when all teachers have high expectations and allow for a variety of learning experiences.

Inductive Classrooms: Inductive classrooms are classrooms in opposition to deductive classrooms. Inductive classrooms have a focus on inquiry and discovery and are often student-centered. Deductive classrooms, in opposition, are more teacher-centered. Inductive classrooms allow students to focus on conclusions drawn from examples and experiences. Yopp (2009) stated, "When students learn strategies for identifying key ideas in inductive arguments, these ideas can be extended to provide more formal proofs" (p. 287).

Justification: Justifying a solution entails having students provide how or why they solved the problem in a way (Wagganer, 2015). Teachers embed justification within the Standards for Mathematical Practice, which are a requirement in the reform-based mathematics and standards-based mathematics classrooms. Students who "are involved in discussions in which they justify solutions, especially in the face of disagreement, will gain better mathematical understanding as they work to convince their peers about differing points of view" (NCTM, 2000b, p. 59). In a math classroom, justification involves convincing others that a statement is valid (Lannin, Barker, & Townsend, 2006).

Explanation: Wagganer (2015) defined explaining as students telling the steps to solve a problem. Justification differs from explaining because justification requires the students to tell how or why they chose a strategy or reached a solution. Explaining the thinking process is an important learning goal of mathematics education reform (Hiebert & Wearne, 1993; NCTM, 2000b).

Procedures

I used a survey design with foundations from Truxaw, Gorgievski, and DeFranco's (2008) instrument (Appendix A). The sample included teachers from a school system in a southeastern state A school system in a southeastern state, and the expected sample size was approximately 1,400. I sent the survey three separate times to distribution lists from the school system. After I gathered data using Qualtrics, I analyzed the data using three factorial ANOVAs in Statistical Package for the Social Sciences (SPSS). Each factorial Analysis of Variance (ANOVA) pertained to a different dependent variable. Additionally, post hoc tests determined significantly diverse groups.

Limitations of the Study

Limitations are features of the study, which may negatively affect the results of the survey or the ability to generalize the results (Roberts, 2010). This study has three main limitations, self-reporting, a lack of generalizability, and a prescribed curriculum. One limitation pertains to the fact the teachers were self-assessing their perceptions using self-reported data. The second limitation imbedded in the structure of the study was a small amount of generalizability of the results. The third limitation is that teachers are following a county mandated pacing, with limited flexibility in choosing which mathematical tasks they wanted to use.

Organization of the Study

This study is a five-chapter quantitative dissertation. Chapter 1 included an introduction to the study, with the subsections of background, the problem statement, conceptual framework, purpose, and research questions. Chapter 2 comprises a thorough review of the literature. Chapter 3 describes the methodology and methods used in the survey study. Chapter 4 contains the research findings organized by research question and hypotheses, and Chapter 5 includes the conclusions, discussions, and suggestions for future studies.

Chapter II

REVIEW OF THE LITERATURE

The NCTM is tenacious in their advocacy for reform-based mathematics. The teaching principle from the NCTM (2000b) refers to reform ideas, which the NCTM has been influencing since 1989. The belief that ambiguity can exist in mathematics is counter-intuitive. Mathematics is a precise language which is used to answer mathematical problems. The body of literature reviewed for this study encompassed numerous diverse and related topics. To clarify the relationships between these diverse topics, I provided a concept map. Figure 1 displays the concept map, which represents the organization of the body of the literature review enclosed.

The shifts, since 1989, have been suggesting changes on mathematics education from rote computation and algorithms to classrooms becoming communities of learning. The authors of the 1991, 1995, and 2000 Professional Standards for Teaching Mathematics discusses three key ideas for discourse: (a) the teacher's role in discourse, (b) the student's role in discourse, and (c) tools for enhancing discourse (NCTM, 2000b). The *Principals and Standards for School Mathematics* from 2000 reflected having teachers using meaningful tasks in the learning environment (NCTM, 2000b). The teaching principle, outlined in *Principals and Standards for School Mathematics*, encourages effective math teaching (NCTM, 2000b). The authors of the additional six standards within the teaching principle addressed “worthwhile mathematical tasks; the teacher's role in discourse; the student's role in discourse; tools for enhancing discourse;

the learning environment; and the analysis of teaching and learning" (NCTM, 2000b, p. 17).

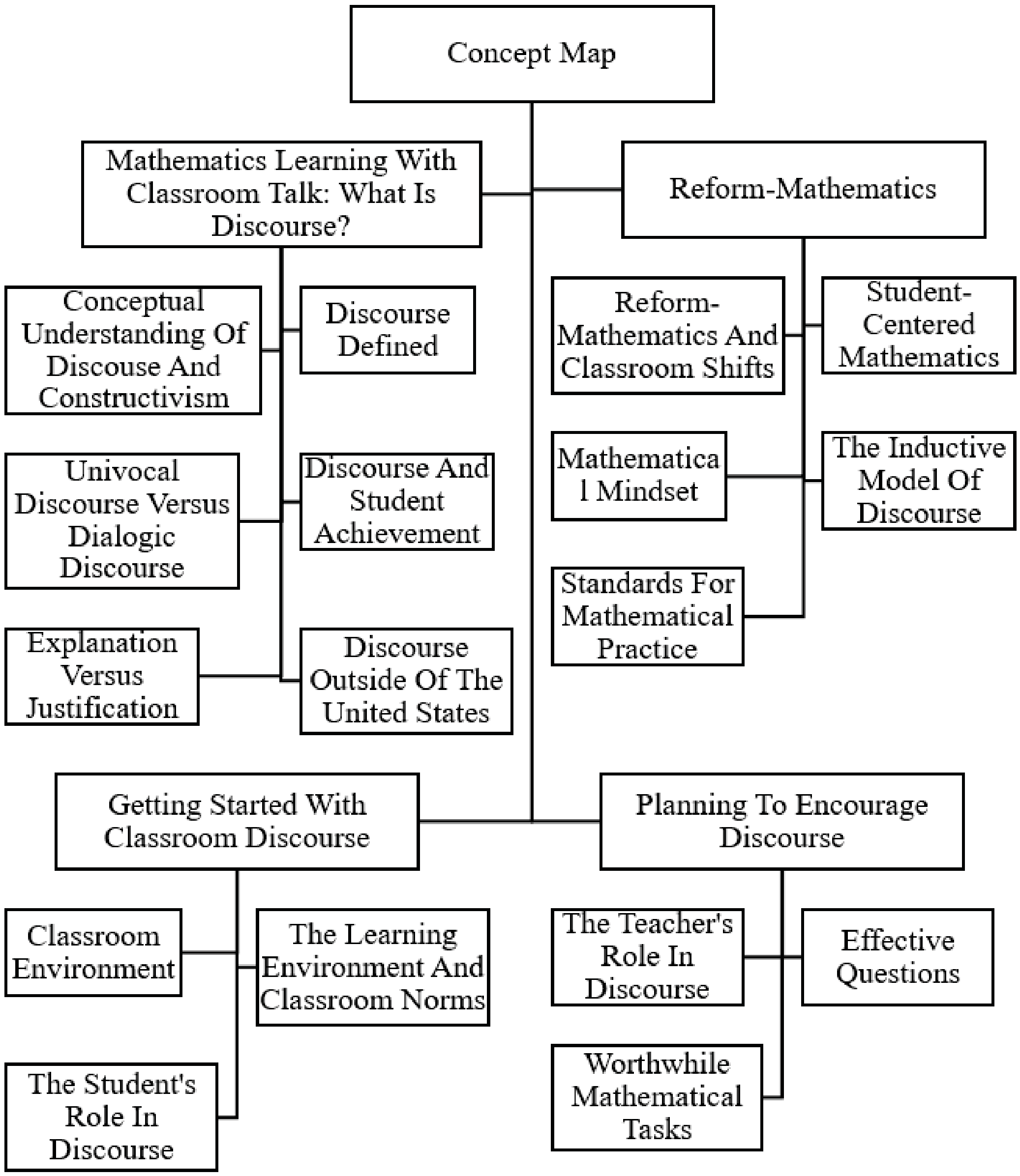

Figure 1. Conceptual Map with An Explanation

Concept Map with Explanation

The literature review encompasses a comprehensive taxonomic overview of discourse regarding mathematics classrooms. I organized the literature review into four overarching categories: discourse, reform-mathematics, getting started with classroom discourse, and planning to encourage discourse. The topic flow chart (as expressed in a concept map) (Figure 1) outlines the literature review topics of the study. This concept map is a sense-making tool that connects numerous ideas and current research topics into four overarching topics: What is Discourse, Reform-Mathematics, Getting Started with Discourse, and Planning to Encourage Discourse.

Conceptual Understanding of Discourse and Constructivism

The concept of constructivism is in sharp contrast to the view that many teachers have towards learning mathematics. Students do not absorb mathematical structures (Clements & Battista, 2009). Teaching must rely on more than simply being the transmission of established facts, skills, and concepts. According to Clements and Battista (2009), five major ideas characterize constructivist mathematics:

1. Children from the learning environment actively create, not passively absorb, knowledge.
2. Children create new mathematical understanding by reflecting on actions and integration of existing structures and knowledge.
3. Individuals have their interpretations of the world. Experiences and interactions shape these interpretations. Learning mathematics is a process of adapting one's world.

4. Learning is a social process. Mathematical understanding is cooperative and mature. Understanding mathematics in the classroom culture involves educators providing students with the time to discover and invent.
5. Sensemaking is a requirement. If the teacher requires students to use a process, students must have an activity to make sense of the method.

The social aspect of constructivism is the specific conceptual foundation for this project. The constructivist teacher, "by offering appropriate tasks and opportunities for dialogue, guides the focus of students' attention, thus unobtrusively directing their learning" (Clements & Battista, 2009, p. 7). Teachers who have constructivist classrooms understand their responsibility as a learning facilitator. Additionally, convincing evidence shows that even young students can explore problems and invent strategies to solve them (NCTM, 2010b).

Dialogic discourse occurs when the teacher intends to understand the students' thinking and uses that thinking as devices for learning. The constructivist teacher is open to students' ideas and will pursue unexpected approaches to a problem to allow students to generate new mathematical understanding socially (Kitchen, 2016; Knuth & Peressini, 2001). In the dialogic model of discourse, students must:

> (a) Actively engage in new mathematics, persevering to solve novel problems; (b) take part in a discourse of conjecture, explanation, and argumentation; (c) engage in generalization and abstraction, developing efficient problem-solving strategies and relating their ideas to conventional procedures; and to achieve fluency with these skills, (d) engage in some amount of practice. (Hattie et al., 2016, pp. 58–59)

An example of dialogic discourse is a teacher re-voicing a student's speech on a specific strategy or structure to a problem. Specifically, teachers can find dialogic discourse at the "stage the summarization through connecting students' mathematical ideas emerged in the classroom" (Saengpun, 2013, p. 198).

Underlying the use of discourse in the mathematics classroom is the "idea that mathematics is about reasoning, not memorization" (Maguire & Neill, 2006, para. 5). Procedures without conceptual understanding are one of many obstacles the NCTM attempts to overcome with its constructivist approach to learning mathematics (NCTM, 2014). The NCTM emphasized shared themes throughout the literature, including the use of mathematical discourse between students and teachers (NCTM, 2000b, 2014). Mathematical discourse encourages productive struggle from students (Boaler, 2016a; NCTM, 2000b, 2014). Productive struggle, as outlined by NCTM, encourages students to grapple with mathematical ideas and relationships. In contrast to productive struggle, "unproductive struggle occurs when students make no progress towards sense-making, explaining, or proceeding with a problem or task at hand" (NCTM, 2014, p. 48). Teaching with productive struggle leads to long-term benefits, with students more able to apply their learning to new problem situations (NCTM, 2014). The productive struggle is evident in a classroom when students ask questions related to the source of the struggle, which helps them progress in understanding and solving tasks. They can help one another without simply giving the answer.

Teachers can implement argumentation and discourse to develop mathematically proficient students. One key instructional strategy for discourse is to introduce false claims. Doing so allows the shift of the mathematical authority to go from the teacher or textbook to the students. Additionally, false claims allow students to understand that invalid claims can be changed and improved (Rumsey & Langrall, 2016). Rumsey and Langrall (2016) suggested, "As students became more adept at using mathematical argumentation, they were better able to support their claims with examples and to challenge others' claims with counterexamples" (p. 418).

Educators often see the productive struggle of students as a weakness, but productive struggle leads to durable proficiency in mathematics content. Incorporating dialogic discourse and rich mathematical tasks allow students to turn such struggles into mathematical discussions, which lead to achievement. Productive struggle helps students build connections to different ideas (Boaler, 2015; McGatha & Bay-Williams, 2013). When students struggle productively, they feel a sense of accomplishment and apply their knowledge (Boaler, 2015; McGatha & Bay-Williams, 2013). Students can subsequently develop a strong self-efficacy for doing mathematics (McGatha & Bay-Williams, 2013). Students in the 21st century must represent problems and justify their conclusions. These skills are learned over time from experiencing productive struggle and discourse within a mathematics classroom (Boaler, 2015).

Dominant cultural beliefs about teaching and learning of mathematics are consistent with ineffective teaching (NCTM, 2014). Many parents and educators believe students should be taught as they were, through memorization and procedures (NCTM, 2014). Too often, parents and teachers are not convinced straying from these beliefs will be more efficient for student learning (Boaler, 2016a; NCTM, 2014). In sharp contrast is the belief that mathematics should center on engaging students in solving and discussing tasks, which promotes reasoning and sense-making (Boaler, 2015; NCTM, 2014).

Teachers who believe this to be true plan lessons that encourage student interactions and discourse to better help students make sense of mathematics concepts (Brickhard, 1997; NCTM, 2014; Stiff, 2001).

A range of cognitive benefits occurs when teachers embed discourse in mathematics lessons. These benefits can include making conjectures, presenting evidence, voicing concerns, agreeing, disagreeing, and supporting one's own thinking (Battista, 1994; Chapin et al., 2009; McGatha & Bay-Williams, 2013). Cognitive learning is an individual's internal representation of learning. Teachers and students may never realize their knowledge is complete, shallow, or passive unless teachers put students in a situation where they must talk or write about a mathematical concept (Chapin, O'Connor, & Anderson, 2009).

Social aspects also play a role in student discourse in mathematics classrooms (Sammons, 2012), which allows students to remember the content. If a teacher makes a claim, a student is less likely to remember that claim. If a student makes the claim, the learning event becomes more memorable due to its social significance. Socially, when students talk in class, they learn about respect and kindness. Students learn to understand to respect someone's point of view and someone's reasoning.

According to Boaler (2016a), a prominent scholar in the field of mathematics education, babies and infants love mathematics. One of the most mathematical acts of all is patterning. Children happily and easily make patterns in colored blocks (Boaler, 2016a). Therefore, students innately enjoy problem solving and puzzles. Enjoyment occurs when discovering and uncovering content takes precedence over teachers covering and recovering content. According to Boaler (2016a), “the best starts we can give our students is to encourage them to play with numbers and shapes, thinking about what patterns and ideas they can see" (p. 34). Following this idea of engaging mathematical concepts through play, children will enjoy mathematics more if the concepts are challenging.

Effective, productive talk must occur in a three-part cycle (Chapin et al., 2009; Weaver et al., 2005). "Student questions lead to explanations and justifications that may be challenged and subsequently defended, which might, in turn, lead to the formation of new generalizations or conjectures, thereby initiating a new cycle" (Weaver et al., 2005, p. 2). The first section of the cycle is planning and projecting, the second part of the cycle is improvising and responding, and the third part of the cycle is summarizing and solidifying (Chapin et al., 2009). During Phase 1 of the cycle, the teacher plans for a specific lesson, spending time on what mathematical concepts are to be learned and misconceptions the students may have. The teacher also needs to plan which types of the talk will be included (whole group, small group, or partner). Phase 2 occurs during the lesson and often includes improvisation and uncertainty about what students will say (Chapin et al., 2009). Last, during the third phase, teachers need to summarize key points and reflect on the lesson. It is critical as a teacher to review, clarify, and solidify important ideas for students to be prepared for the next day's lesson.

Throughout the cycle of discourse, several types and levels of discourse occur (Weaver et al., 2005). These types can reflect a scale or levels of discourse (Weaver et al., 2005). Answering a question, for example, is Level 1 discourse, whereas relating one's thinking to another's is Level 6 discourse (Table 1). Answering, making a statement or sharing, explaining, questioning, challenging, relating, predicting or conjecturing, justifying, and generalizing represent the different levels of mathematical discourse that can occur throughout the cycle of discourse (Weaver et al., 2005, pp. 2–3)

Table 1

Levels of Mathematical Discourse

Level	Definition	Explanation
1	Answering	A student gives a short answer to a direct question from the teacher or another student.
2	Making a Statement or Sharing	A student makes a simple statement or assertion or shares his or her work with others and the statement or sharing does not involve an explanation of how or why. For example, a student reads what she wrote in her journal to the class.
3	Explaining	A student explains a mathematical idea or procedure by stating a description of what he or she did, or how he or she solved a problem, but the explanation does not provide any justification of the validity of the idea or procedure.
4	Questioning	A student asks a question to clarify his or her understanding of a mathematical idea or procedure.
5	Challenging	A student makes a statement or asks a question in a way that challenges the validity of a mathematical idea or procedure. The statement may include a counterexample. A challenge requires someone else to reevaluate his or her thinking.
6	Relating	A student makes a statement indicating he or she has made a connection or sees a relationship to some prior knowledge or experience.
7	Predicting or Conjecturing	A student makes a prediction or a conjecture based on his or her understanding of the mathematics behind the problem. For example, a student may recognize a pattern in a sequence of numbers or make a prediction about what might come next in the sequence or state a hypothesis regarding a mathematical property they observe in the problem.
8	Justifying	A student provides justification for the validity of a mathematical idea or procedure by providing an explanation of the thinking that led him or her to the idea or procedure. The justification may be in defense of the idea challenged by the teacher or another student.
9	Generalizing	A student makes a statement that is evidence of a shift from a specific example to the general case.

Note. Adapted from "Oregon Mathematics Leadership Institute's classroom observation protocol," by D. Weaver, T. Dick, K. Higgins, K. Morromgelle, L. Foreman, N. Miller, and N. Rigelman, 2005, *RMC Researcher Corporation,* pp. 1–16.

History of Discourse within the National Council of Teachers of Mathematics

One of the most defining events shaping the current mathematics education was the launching of the Sputnik 1 by the Soviet Union in 1957. Some scholars began thinking the United States was falling behind in areas of math and science education. This concern spurred changes in mathematics education during the 1960s and 1970s (Burris, 2014). After several failed attempts, the NCTM in 1975 published an outline which would soon lead to a set of content standards.

In 1980, the NCTM published An Agenda for Action (NCTM, 1980). This publication outlined 10 recommendations for kindergarten through twelfth grade mathematics programs (NCTM, 1980). Next, in 1989, the council released and published a revolutionary document, *Curriculum and Evaluation Standards for School Mathematics*, which focused on a shift towards critical thinking in mathematics education. This document is sometimes referred to as the NCTM Standards. Throughout this document the NCTM stresses problem solving, communication, connections, and reasoning. Emphasis on communication (among other things) began to increase. Eventually, this original document was expanded in 1991, 1995, and again in 2000 with NCTM's book, *Principles and Standards for School Mathematics*. The 1991 version was titled *Professional Standards for Teaching Mathematics,* and the 1995 version was titled, *Assessment Standards for School Mathematics.*

The NCTM book, *Principles and Standards for School Mathematics,* is still one of the most accepted sets of mathematics standards from pre-kindergarten through twelfth grade. Such standards align with college and career readiness standards for the twenty first century. This NCTM published this book as a resource guide for any decision maker or stakeholder in math education (NCTM, 2000b).

The 2006 *Curricular Focal Points* builds on the 2000 document and "this new publication is offered as a starting point in a dialogue on what is important at levels of instruction and as an initial step toward a more coherent, focused curriculum in this country" (Schielack et al., 2006). The 2006 *Curriculum Focal Points* outlines the most important mathematical topics for each grade level which influenced the publication of the Common Core State Standards.

One principle in the NCTM's 2000 book *Principles and Standards for School Mathematics* is the teaching principle. The teaching principle, embedded in the NCTM (2000b) *Principles and Standards for School Mathematics* makes the case that students must have opportunities to learn important mathematics under the guidance of competent and committed teachers (NCTM, 2000b). Math teaching "requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (NCTM, 2000b, p. 369). Additionally, the *Principles to Actions* (NCTM, 2014) notes teachers must take the following actions regarding the teaching principle:

- Consistently implement the eight Mathematics Teaching Practices (SMP);
- Elicit, value, and celebrate varied approaches and solution paths that students take to solve mathematics problems, explain their thinking, and critique the arguments of others;

- Give priority to the mathematical practices, including problem-solving, reasoning, and constructing viable arguments in every aspect of classroom practice—including teaching, assessment, curriculum decisions, and the use of tools and technology;
- Plan and implement units and lessons that promote positive dispositions toward the study of mathematics, including curiosity, self-confidence, flexibility, and perseverance. (p. 114)

Discourse Defined

According to the NCTM (2014), effective math teachers facilitate discourse among students. This discourse builds a shared understanding of mathematical ideas and allows students to analyze and compare ideas. Teachers and parents learned mathematics through memorizing facts, formulas, and procedures and then practicing skills repeatedly. The NCTM noted straying from this notion establishes a more efficient mathematics learning environment. "Effective mathematics teaching engages students in discourse to advance the mathematical learning of the whole class. Mathematical discourse includes the purposeful exchange of ideas through classroom discussion, and through other forms of verbal, visual, and written communication" (p. 29). Additionally, Otten et al. (2015) defined discourse as communication to convey a message by written and spoken language.

Mathematical classroom discourse includes the persistent exchange of ideas through classroom discussion and through other forms of communication (NCTM, 2014). Mathematics-talk communities are places where students can have meaningful math discussions to construct knowledge and support learning of others in the group. In a math community, teachers guide the learning and extend understanding through facilitating inquiry with students. Through questioning, teachers can scaffold students' education (Kimani et al., 2016). Math communities share a common goal of learning mathematics and foster student communication of mathematical ideas (Hufferd-Ackles, Fuson, & Sherin, 2004).

Before productive mathematical discussions, teachers should first establish a clear and accurate goal for learning, and then teachers should select a high-level mathematical task to match the learning target (Smith & Stein, 2011). According to the beliefs of reform mathematics, it would be counterproductive to begin a lesson to tell students exact definitions, formulas, or rules because doing so does not allow the students to construct meaning (NCTM, 2014).

Learning mathematics is a social endeavor achieved through using classroom discourse (Sammons, 2012). Griffin, League, Griffin, and Bae (2013) collected data describing the practices of mathematics instruction used to monitor learning of the students with disabilities. The study results suggest math teaching supports learning of students with disabilities and other struggling students, if the teaching includes strategy instruction, offers frequent opportunities for review and practice, and entails concept development (Griffin et al., 2013).

Moreover, a productive belief is establishing a classroom in which the teacher engages students in tasks that promote reasoning and problem solving toward a shared goal of mathematics understanding (NCTM, 2014). An effective mathematics teacher "facilitates discourse among students to build a shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments" (NCTM, 2014, p. 29). Time spent on definitions is a lower level demand (Smith & Stein, 2011).

Nonetheless, the first step to creating mathematical discourse is to create an open classroom that allows students to express their ideas (Hufferd-Ackles et al., 2004). This development is a critical first step in achieving a community of learners and discourse in the mathematics classroom. Hufferd-Ackles et al. (2004) suggested an active mathematics-talk community could occur in an urban classroom. Additionally, teachers found it beneficial to collaborate with one another during after-school meetings and noted that the experiences students have in math class involved critical thinking and reasoning (Kilic et al., 2010). Under the new standards, students can accurately communicate their mathematical thinking to others and instruction can pertain to mathematical awareness and independence. Kilic et al. (2010) defined discourse as asking questions, making conjectures, and checking for reasonableness.

For discourse to work efficiently in a mathematics classroom, students must begin their conversations with a theory and express their own ideas. Students can then hear opinions of others to make sense of mathematics. Students are required to explain their claims (Kilic et al., 2010). Students and educators practice actively listening to the thinking of others, and students are encouraged to test multiple hypotheses with various strategies. Teachers must listen to students without testing the students (Kilic et al., 2010). Summative and formative evaluation does not occur at this point in the discourse. Students are encouraged to offer alternative solutions and expose classmates to other ways of thinking about the same task (Kilic et al., 2010).

Some teachers feel discourse begins when students share ideas and talk in class. This discourse, however, is not a true learning community because a learning community contains an environment where everyone is involved in an effort of understanding the topic under study (Manouchehri & St. John, 2006). When discourse becomes a learning community, discourse requires participation, commitment, reciprocity, content, and purpose (Manouchehri & St. John, 2006). In a learning environment, the structure of discourse differs from old methods of teaching mathematics.

In traditional methods of teaching, discourse transfers information (Manouchehri & St. John, 2006). The structure of a learning community is multidirectional and responsive, and during the verbal exchange, discourse requires reflection and action. The content of a learning environment where discourse occurs involves seeking connections to other ideas. The direction and destination of discourse are not always predictable (Manouchehri & St. John, 2006). Discourse in a learning community allows the students and the teacher to learn more about the content (Manouchehri & St. John, 2006).

Classroom moves include building a positive classroom community, allowing equal talk time, and asking open-ended questions (Rawding & Willis, 2012). If students are struggling with a topic, it is standard practice for teachers to ask students, "How do you know?" The consistent practice allowed students to learn how to interact in a way that keeps them focused on the mathematics (Rawding & Willis, 2012). A discourse move is "a deliberate action taken by a teacher to encourage, facilitate, take part in, or influence the discourse in the mathematics classroom" (Springer & Dick, 2006, p. 106).

After working with 110 students and four teachers from fifth-grade classrooms in a Midwestern school district, Kilic et al. (2010) found asking students to explain their reasoning encouraged them to consider multiple methods to a solution. Having students explain their work allows the teacher to evaluate student understanding. Kilic et al. (2010) suggested teachers offer feedback for informal assessment to guide thinking and encourage an alternative solution besides supporting testing hypotheses. Facilitation of discourse may promote further discussion or may derail student thinking. Kilic et al. (2010) suggested requiring explanations and justification from students and for teachers to offer feedback pertaining to the students' thinking. Techniques for improving small group discourse include requiring explanations from the students, offering feedback, and encouraging alternative solutions. The teacher should assist in focusing students' thinking and listen to their students without testing them.

Univocal Discourse versus Dialogic Discourse

Univocal discourse emphasizes sending an exact message. Blanton, Berenson, and Norwood (2001) analyzed linkages between classroom discourse and learning to teach mathematics. Additionally, univocal discourse can be referred to as "a maximally accurate transmission of a message" (Truxaw & DeFranco, 2008, p. 489). Discourse provides a path of interaction between students and teachers (Blanton et al., 2001). Discourse in the mathematics classroom has a dualistic structure as the sender and the receiver. In other words, discourse is used twofold: to convey meaning and to generate meaning (Blanton et al., 2001; Knuth & Peressini, 2001; Truxaw & DeFranco, 2008). Teachers use univocal discourse to convey meaning. *Dialogic discourse* is the term used to generate meaning (Blanton et al., 2001; Knuth & Peressini, 2001).

Univocal discourse is characterized by communication "in which the listener receives the 'exact' message that the speaker intends for the listener to receive" (Knuth &

Peressini, 2001, p. 321). Knuth and Peressini (2001) pointed out that once meaning is conveyed, univocal communication is considered successfully finished. An exchange between teacher and student can be regarded as univocal when the teacher does not try to understand the student's method (Knuth & Peressini, 2001). Interactions are univocal when the teacher's intention is to convey a message that students should use an approach to a problem (Knuth & Peressini, 2001). However, in most classrooms, the teacher's point of view dominates and reflects an overuse of univocal discourse (Truxaw & DeFranco, 2007). In contrast, dialogic discourse is characterized by give-and-take or two-way communication (Truxaw & DeFranco, 2007, 2008; Knuth & Peressini, 2001). The listener receives the same message, but at this point, the univocal discourse ends, and the dialogic discourse begins (Knuth & Peressini, 2001). Communication mismatch can be a springboard for inquiry (Knuth & Peressini, 2001). Student understanding deepens when students can use their statements to make meaning of mathematics.

Consequently, all dialogic discourse must contain some univocal discourse for clear communication to take place (Blanton et al., 2001; Knuth & Peressini, 2001). Classrooms, in which teachers incorporate dialogic discourse, involve questioning, validating, and justifying (Blanton et al., 2001) and these are embedded within process standards of the NCTM (2000a). The essence of dialogic discourse includes the students' solution approaches, teacher comments, and task choice (Knuth & Peressini, 2001). The visions of the NCTM denote classrooms in which both faculty and students use dialogic discourse, and both are responsible for contributing to discussions (Knuth & Peressini, 2001; NCTM, 2000b, 2014). Different discourse types emerge as students solve various tasks. Both univocal and dialogic become appropriate forms of discourse, depending on the daily instructional goals (Knuth & Peressini, 2001).

Often, univocal discourse and dialogic discourse are referred to as passive or active interpretation, respectively (Blanton et al., 2001). The quality of discourse and type of discourse are critical for promoting mathematical understanding (Truxaw & DeFranco, 2007, 2008). "Dialogic Discourse connotes social relationships of equal status, intellectual openness, and possibilities for critique and creative thought" (O'Connor & Michaels, 2007, p. 277).

Discourse and Student Achievement

Vygotsky (1978) encouraged the use of discourse to develop interest between learners and teachers. Students who identify strongly as mathematically competent demonstrate higher achievement on assessments and classwork (Hung, 2015). Teachers can ask questions throughout the lesson, not just at the end to check for understanding (Marzano, Pickering, & Pollock, 2001). "'Higher level' questions produce deeper learning than 'lower level' questions" (Marzano et al., 2001, p. 113). Higher-level questions tend to produce deeper levels of knowledge (Marzano et al., 2001). Hung (2015) noted a link between his students' self-perceptions, participation in discussions, and achievement in mathematics. Researchers have determined a direct relationship between students who engage actively in mathematics and achievement at elevated levels (Boaler, 2002, 2008; Boaler, Williams, & Confer, n.d.). Scholarly disagreement is beneficial and needed for academic growth and achievement (Stinson, 2012). If students are not given opportunities to be challenged and given challenging work, they do not achieve at elevated levels (Boaler, 2015).

In one study in England, Boaler (2015) concluded teacher expectations led to student achievement. International comparisons show the United States do not offer as many high-level mathematics classes as most other countries do (McKnight et al., 1987). Boaler (2016a) outlined one of her studies of Chinese American calculus students and African American calculus students, highlighting that the major difference was the Chinese American students had a higher success rate because of working together. When students work on mathematics collaboratively, equitable outcomes result (Boaler, 2016a).

Explanation versus Justification

Classroom discourse is almost impossible to avoid when students are challenged with tasks that require them to explain their thinking, and justify why their process works (Lannin, Barker, & Townsend, 2006). Constructing and evaluating arguments to justify or invalidate a generalization is a challenging task for most students (Lannin et al., 2006). In the math classroom, justification involves convincing others that a statement is valid and determining such a valid justification comes from the social interactions they experience with the teacher and with other students. Justifications develop an understanding that permits others to construct generalizations for similar situations (Lannin et al., 2006; SanGiovanni, 2016).

Justifications fall into four broad categories (Lannin et al., 2006). The first category is no justification (or procedural justification), which entails simply stating rules without describing why. This leads the child to believe rules generalize the mathematics to all cases. The second type is empirical justification, in which a child extends his or her justification by testing several cases. The third category is generic examples when an example is used to communicate generality across cases. Last, the fourth category is a deductive justification—a justification that provides a general argument that clearly explains why the rule applies to all cases of the situation (Lannin et al., 2006). Students eventually move beyond the focus of specific calculations and move toward construction of generalizations by creating valid justifications for general statements (Lannin et al., 2006).

Discourse Outside of the United States

Other countries experience similar situations as the United States and some encounter different situations pertaining to mathematics education. Dogruer, Mine, and Yusuf (2015) conducted a case study on mathematical discourse in a fifth-grade classroom. Dogruer et al.'s case study in Turkey, for example, showed that despite the recent reform efforts in mathematics in Turkey, teacher-centered instruction continued to be the dominant instruction method. Based on student reports, students in Singapore and Hong Kong provided similar responses of value in teacher explanations and demonstrations (Kaur, Anthony, Ohtani, & Clarke, 2013). Students from both countries reported the "report back sessions" were beneficial to check their answers and allow relearning to take place (Kaur et al., 2013). Singapore students also reported an appreciation for opportunities for group work as an additional source of practice (Kaur et al., 2013).

Hemmi and Ryve (2014) explored effective teaching in Finland and Sweden and reported on teacher educators' discourses. Hemmi and Ryve conducted their study with highlighting discourse practices in Finnish classrooms and Swedish classrooms. Hemmi and Ryve analyzed materials, classroom data, and feedback in discussions to study mathematics achievement. The Swedish discourse has similar features of the discourse suggested by the NCTM for the United States. Finnish discourse was more analogous to that in Asian countries.

Both Sweden and Finland scored below the United States in contemporary Trends in International Mathematics and Science Study testing (Hemmi & Ryve, 2014). However, several aspects of the recent international reform movements are visible in the discourses from both countries. Sweden and Finland do not use a difference in the relationship between understanding and memorizing as in the United States (Hemmi & Ryve, 2014). Swedish educators conceptualized effective teaching as building on students' ideas from everyday situations. Using everyday situations is more closely aligned with NCTM ideas of reform mathematics. Contradicting beliefs of the NCTM, Finnish teachers stress the importance of memorizing algorithms and emphasize the importance of a clear presentation of mathematics, routines, and homework (Hemmi & Ryve, 2014).

Singapore math has similar themes as outlined by the NCTM. Both Singapore mathematics and the NCTM reform mathematics emphasize a need to justify thinking, compose numbers, and decompose numbers to build number sense. Boaler (2008) examined high achievement and equity in mathematics to relate a longitudinal study of three California schools to the popular approach used in the United Kingdom. Student achievement "came about through a mathematics curriculum that was widely abstract but that enabled multiple methods, solution paths, and points of discussion and negotiation" (Boaler, 2008, p. 169). European mathematics research emphasizes teaching values, such as communications skills, to show academic achievement (Boaler, 2008). Teachers showed that conversations could be used to aid mathematical understanding and, in turn, increase achievement (Boaler, 2008). In conclusion, a wide variance in expectation in classrooms exists from Melbourne, Hong Kong, Shanghai, Berlin, Tokyo, Singapore, Seoul, and San Diego regarding the expectation and opportunities for students to engage in classroom discourse (Kaur et al., 2013). Boaler described a case at Railside School where students showed more gains in achievement than the other two schools analyzed (Boaler, 2008). One reason was the implementation of discourse and communication in the classrooms (Boaler, 2008).

Reform-Mathematics and Classroom Shifts

Constructivists seek an understanding of the world in which they live and work in; throughout the past 20 years, the discussion has centered on reform in mathematics (Battista, 1994). This discussion led the NCTM to publish proposed reforms for primary and secondary mathematics classrooms. Among this debate was a goal for students to become doers and thinkers of mathematics (Smith & Stein, 2011). The implications of this effort are that doing mathematics requires complex (non-algorithmic) thinking, embedded in rich mathematical tasks (Smith & Stein, 2011). Similarly, doing mathematics requires students to explore and understand mathematical concepts, processes, and relationships (Smith & Stein, 2011). Such reform also suggests that teachers shift from the transmitter of knowledge, to a system where students take an active role in their learning (Larsen & Bartlo, 2009; McGatha & Bay-Williams, 2013). Hufferd-Ackles, Fuson, and Sherin (2004) stated verbal interchanges are associated with outcomes or understanding.

Teachers in the 21st century are seeing a shift in the way they are expected to have students engage in and learn mathematics (Wagganer, 2015). “Because traditional instruction ignores students' personal construction of mathematical meaning, the development of their mathematical thought is not properly nurtured, resulting in stunted growth" (Battista, 1999, p. 424). With less focus on correct answers and more focus on critical thinking, teachers are charged with compelling students to provide meaningful explanations to support higher-level mathematical thinking and reasoning (Jabari, 2016; Kilpatrick & Swafford, 2013; Stein, Groover, & Henningsen, 1996). O'Connor and Michaels (2007) stated, "If we are serious about supporting students to go beyond the given, to challenge the arguments of others with evidence, to generate novel interpretations or analyses, they need extensive practice in doing this kind of intellectual work" (p. 284).

Critical thinking increases with discourse embedded in the classroom (NCTM, 2000b, 2014). Effective discussions focus on thinking critically. The NCTM (2000b) *Principles and Standards for School Mathematics* outlined reform mathematics. According to the NCTM theories of communication, instructional programs should enable students to do the following (a) organize and consolidate their mathematical thinking through communication; (b) communicate their mathematical thinking coherently and clearly to peers, teachers, and others; (c) analyze and evaluate the mathematical thinking and strategies of others; and (d) use the language of mathematics to express mathematical ideas precisely.

Boaler (2002) explored the relationship between reform mathematics and equity. An excellent mathematics program requires all students to access quality curriculum, effective teaching and learning, and resources needed to maximize learning (NCTM, 2014). "Equity does not mean that every student should receive identical instruction;

instead, it demands that reasonable and appropriate accommodations are made as needed to promote access and attainment for all students" (NCTM, 2014, p. 59). Throughout the research, constant discussions pertained to reform-based mathematics, and whether reform-based mathematics enhance achievement for all students (Boaler, 2002). Some researchers have argued open-ended type questions lead to measurable success, while others prefer traditional methods for learning math (Boaler, 2002).

Boaler (2002) found reform approaches promote equity and high achievement, and were important to understand how some methods differ from others. Teachers often conflate equity in school mathematics outcomes with equality of inputs (NCTM, 2014). A shift from what students cannot do to a change of what schools can do is necessary to make educational experiences fairer (Boaler, 2002). When teachers emphasized problem-solving, communication, and conceptual understanding, mathematical sense-making becomes attainable (Boaler, 2002). In addition, teachers need to encourage students to explain and justify their knowledge. Making real-world context accessible is equally important to attaining student achievement and justification of knowledge. Moreover, equity requires accommodating differences to help everyone learn mathematics.

Whitenack and Yackel (2002) supported constructivist mathematics. Mathematical reasoning becomes a natural part of the class during the discussion with peers (Whitenack & Yackel, 2002). One example noted by Whitenack and Yackel was the starting point for classmates to develop arguments to support or refute each other's ideas. Determining whether a student is explaining or justifying a conclusion requires teachers to consider the purpose of the discussion. Sometimes, students demonstrated their learning to clarify; other times, students were told to validate thinking or justify an action. When defending or explaining, students revisited their mathematical ideas and thinking and helped build a convincing argument for the student speaking and the student's peers. Children must have adequate time to engage in working independently as well as time to engage in classroom discussions (Whitenack & Yackel, 2002). In addition, students must first convince themselves of their understanding, as they solve the problem, to develop arguments in which they explain and justify their solution methods to others (Whitenack & Yackel, 2002). Through reasoning, students develop or refine ideas to explain and justify their thinking. Reasoning allows students to engage in reform mathematics, which is not merely arriving at a correct answer, but also explaining mathematical ideas (Whitenack & Yackel, 2002).

In this changing world, those who understand, and can-do mathematics will have significantly enhanced opportunities and options for shaping their futures (NCTM, 2000b). Bay-Williams (2013) worked with the precision of language and found five language substitutions when teaching fractions. Bay-Williams highly suggested using the term *partitioning* rather than *dividing* when discussing part-whole relationships of fractions. Fractions should be named as opposed to using the *over* terminology (Bay-Williams, 2013). Three-eighths would be the preferred language as opposed to three over eight. Three-eighths shows the iteration of one-eighth, two eights, and then three-eighths. Repetition develops an understanding of the division of fractions (Bay-Williams, 2013). Bay-Williams recommended the term *simplifying* rather than *reducing*. Reducing fractions suggests to students that the fraction changed size (Bay-Williams, 2013). Precise language, particularly when focusing on fractions, plays a significant role in students understanding of mathematics, especially pertaining to fractions. “When students are challenged to communicate the results of their thinking to others verbally or in writing, they learn to be clear, convincing, and precise in their use of mathematical language” (NCTM, 2000b, p. 4).

Lim, Kim, Stallings, and Son (2015) worked with two 45-minute class periods of ninth-grade algebra students in which the teacher encouraged the students to use multiple approaches to problems and share their mathematical thinking. Lim et al. found cognitively demanding tasks enriched learning and encouraged mathematical communication. The lesson used provided sequence and structure, as well as offered classroom norms to develop a sense of community. The tasks engaged students in a productive struggle. Allowing students to communicate their mathematical thinking developed students' sense of belonging to a classroom community. Lim et al. presented teaching practices that developed different thinking. Diverse thinking converged from a productive discourse classroom. Lim et al. allowed students the opportunity to speak and focused the conversation on students' questions.

McGatha and Bay-Williams (2013) created a guide to support teacher leaders who work with mathematics to cultivate classrooms with a focus on developing mathematical practices. McGatha and Bay-Williams created a framework for teacher leaders to support a shift in classroom practices effectively. The Leading for Mathematical Proficiency (LMP) framework explained the SMP-required shifts in classroom practice, which included teaching skills. The cycle continued as teaching skills supported shifts in classroom practice, which provided opportunities to learn more about the Standards for Mathematical Practice. The Leading for Mathematical Proficiency framework had three components: Standards for Mathematical Practice, shifts in classroom practice, and teaching skills. McGatha and Bay-Williams iterated The Leading for Mathematical Proficiency framework guides development of a change in culture. McGatha and Bay-Williams encouraged teachers to instruct by using questioning, which supports the progress of the development of such a culture to engage in the Standards for Mathematical Practice. Within their research, the teacher pressed the students for explanations when she gave students time to work with partners and explain why their conjecture was right. Along with the component of shifting towards explanations, is a change towards engaging students in productive struggle or productive disposition. Teachers must shift from having students explain to justifying their solution and method.

Student-Centered Mathematics

Hiebert and Wearne (1993) worked with six second-grade classrooms; two classrooms used an alternative approach to textbook-type teaching. The researchers' results suggested the relationships between teaching and learning were because of environment and relationships. Hiebert and Wearne analyzed discourse following two features: who talked and how much they talked. The average number of words ranged from 644 to 1,827 words. Hiebert and Wearne concluded the problem-solving type of instructional tasks and classroom discourse occurred together which has positive outcomes for student achievement. Thus, teachers understand the value of talk time for students.

Likewise, Jansen (2009) worked with 148 prospective elementary school teachers regarding motivation in mathematics classroom discussions. Jansen noted classroom discourse provided teachers opportunities to develop their understanding of mathematics as well as make connections to alternative strategies for use in the classroom. The purpose of Jansen's work was to describe what motivates prospective elementary teachers in discussions during mathematics content courses. Jansen further stated participants had limited views regarding the purposes of discussions. Often, teachers were motivated during discussions to demonstrate their competence in mathematics to others. Lampert (1990) worked with a class of fifth-graders and likened changing the way students do and learn mathematics to learning to dance. Students had to tell, show, and do mathematics with the teacher. Experiences from Lampert's research carried into the future for the participants. Lampert discovered patterns of students who were learning and knowing mathematics that occurred through classroom discourse practices. Lampert noted students who typically were fluent in following rules were resistant to accept calculations via another medium.

Otten, Cirillo, and Herbel-Eisenmann (2015) studied two middle and high school mathematics classrooms and found 15–20 percent of the class time was spent reviewing homework. Otten et al. found a method that served as an opportunity to turn the homework dilemma into an opportunity for discourse in both spoken and written language as well as other forms of communication. Otten et al. iterated discourse goes together with the Standards for Mathematical Practice. The system created by Otten et al. shifts from typical homework into one, which promoted the use of the Standards for Mathematical Practice. A focus on correct solutions limits failure as a launching point for discussion. Such failure can be beneficial for student learning. Otten et al. suggested a focus on the big mathematical ideas as opposed to the mechanics of one problem. The researchers also discussed looking for regularity and reasoning abstractly, especially when talking about multiple problems. Otten et al. observed that if teachers focused on correct solutions, then they had limited payoff of using incorrect answers for discussion points, which were beneficial for learning. A focus on correct solutions leads to the conclusion that discourse should be directly tied to the Standards for Mathematical Practice to be most effective.

Russo (2016) designed the co-construction process to create an alternative to assist students who are struggling or those people with a negative attitude towards mathematics. Russo expressed that when students drive the curriculum, they are spending time on what the students consider important. Russo reported his students constructed five main ideas, three of which were in his traditional curriculum. Russo generalized his findings, so all teachers can incorporate students' ideas and life experiences into classroom discourse. Russo reported increased student input when using the co-construction model with his students. Smith and Stein (2011) noted:

> Tasks that ask students to perform a memorized procedure in a routine manner lead to one type of opportunity for student thinking; tasks that demand engagement with concepts and that stimulate students to make connections lead to a different set of opportunities for student thinking. (p. 15)

Researchers can organize discourse in the classroom by levels (Hoffman, Breyfogle, & Dressler, 2009; Hufferd-Ackles et al., 2004). A classroom with a level 0 of discourse is teacher-centered, and the teacher is the primary questioner and authority of the correctness. Level 0 discourse classrooms involve students who are learning passively and only share out short answers when prompted by the teachers. In a Level 1 discourse classroom, the teacher begins to share the responsibility of learning, but student explanations are still brief. In a Level 2 discourse classroom, the teacher and students share responsibility for teaching. Students are involved in questioning one another, explaining, and defending their work to build on ideas from their peers. Last, in a Level 3 discourse classroom, the teacher "serves a more peripheral role. Without prompting from the teacher, students question one another, explain, and justify their ideas, and work together to compare and contrast strategies and solutions" (Hoffman, Breyfogle, & Dressler, 2009, p. 234).

Mathematical Mindset

Mathematics by nature is engaging (Boaler, 2016b). Boaler (2016b) has studied why children do not like, and often fail, in math class. Boaler noted a significant gap in what happens in schools and at home as well as a gap in what occurs in other countries around the world. A mathematical mindset is centered on opportunities for creativity, discussions, and multiple perspectives (Boaler, 2016a; Larsen & Bartlo, 2009). Boaler suggested letting students "know that everyone is a math person and that the latest research is telling us that students can reach any levels in math because of the incredible plasticity of the brain" (Youcubed at Stanford, 2017, para. 1). Having productive struggle in a classroom is a valuable component of planning and preparation for learning. Both teachers and students must share this mindset equally. The NCTM (2016) stated, "Being able to implement this mindset produces students who are tenacious problem solvers and productive communicators who understand the value of mathematical justifications" (para. 2).

Making mistakes in the math classroom strengthens perseverance and the development of neurological pathways, leading to improved outcomes (Boaler, 2016a). Negative feelings about mathematical ability can result in students having a negative engagement with mathematics throughout their school life (Boaler, 2016a). When students make a mistake in math, their brains grow, synapses fire and connections occur (Boaler, 2015). The mindset of teachers is altered when teachers and students feel that making mistakes in math represents a learning achievement, as opposed to a learning failure (Boaler, 2015).

The Inductive Model of Discourse

Teachers often associate inductive classrooms with dialogic discourse (Truxaw & DeFranco, 2007). The inductive teaching model mirrors a dialogic discourse cycle. Because discourse is cyclical in its univocal and dialogic nature, the inductive model is closely associated with dialogic discourse. In classrooms that are inductive in nature, teachers and students move from specific content to conjectures and finally form general hypotheses regarding the topic (Truxaw & DeFranco, 2008). Truxaw and DeFranco (2008) suggested the inductive model of discourse results in the highest percentages of learning talk. The findings from this research indicate that verbal moves are associated with outcomes of learning. In the study, the teacher of the inductive model classroom held certain expectations regarding what the students would learn, the teacher had worked through the problem in advance, and the teacher had anticipated potential pathways for enhancing learning outcomes. The teacher was purposeful and intentional in using talk to help the students discover the principle being covered. The inductive classroom model offers teachers an approach to align their classrooms with current reform initiatives (Truxaw & DeFranco, 2008).

Standards for Mathematical Practice

The Common Core State Standards provide a comprehensive set of standards pertaining to what students are expected to learn. Embedded within the Common Core State Standards are the eight cognitive strategies, which are named the Standards for Mathematical Practice. The Standards for Mathematical Practice suggest how students best learn math content. The Standards for Mathematical Practice are behaviors embedded in the content and describe how students should be interacting with the mathematics. The eight Standards for Mathematical Practice are:

1. Make sense of problems and persevere in solving them,
2. Reason abstractly and quantitatively,
3. Construct viable arguments and critique the reasoning of others,
4. Model with mathematics,
5. Use appropriate tools strategically,
6. Attend to precision,
7. Look for and make use of structure, and
8. Look for and express regularity in repeated reasoning.

With the adoption of Common Core State Standards and the shifts in mathematics, teachers place a focus on coherence and how students think (Mates, 2016). The Standards for Mathematical Practice describe mathematical ways of thinking, and not all those ways are appropriate for every task or lesson. Mates (2016) suggested, "Considering which lessons have genuine opportunities for students to use particular mathematical practices, addressing all eight within the span of a unit, or across several units, rather than in each lesson" (p. 94). The Common Core State Standards for Mathematical Practice specify that students "solve real-world and mathematical problems by working effectively with peers; formulating, communicating and critiquing arguments; and persevering through difficulty. As students internalize these mathematical practices, they engage interpersonal and intrapersonal skills, also known as social and emotional learning competencies" (Charles A. Dana Center at The University of Texas at Austin, 2016, para. 2).

Discourse in a classroom becomes particularly evident when using the Standards for Mathematical Practice Number 3: construct viable arguments and critique the reasoning of others. Teachers can ask questions that specifically elicit this Standard for Mathematical Practice. Some recommended questions, according to the Oregon Response to Intervention and Instruction (n.d.) include, "How is your answer different than _____'s?; How can you prove that your answer is correct?; What math language will help you prove your answer?; What examples could prove or disprove your argument?; What do you think about _____'s argument, what is wrong with ____'s thinking?; and what questions do you have for ____?" (Oregon Response to Intervention and Instruction, n.d., p. 1).

Some recommended questions according to the Louisiana Department of Education (2013) include, "What mathematical evidence would support your solution?; How can we be sure that . . . ?; How could you prove that . . . ?; Will it still work if . . . ?; what were you considering when . . . ?; How did you decide to try that strategy?; How did you test whether your approach worked?; How did you decide what the problem was asking you to find? (What was unknown?); Did you try a method that did not work?; Why didn't it work?; Would it ever work?; Why or why not?; What is the same and what is different about . . . ?; and How could you demonstrate a counter-example?" (Louisiana Department of Education, 2013, p. 3).

Classroom Environment

Effective teaching requires "a challenging and supportive classroom learning environment" (NCTM, 2000b, p. 17). First, teachers must establish a clear and accurate goal for the mathematics to be taught to create a discourse-rich environment (Smith & Stein, 2011). Fernsten (2007) claimed writing allows graduate teachers to dispel writing fears and furthers mathematical understanding. Writing in class can help teachers assess student understanding and analyze students' ability to solve problems and apply knowledge. Students who partook in writing workshops used multiple types of expression. Productive discussions, therefore, are unlikely to transpire if the task requires limited thinking and reasoning (Smith & Stein, 2011).

Like Fernsten (2007), Bostic and Jacobbe (2010) considered that the classroom environment and having students feel comfortable sharing their solutions were crucial for developing a positive culture and allowing for problem-solving discourse. Students noted they saw many opportunities to learn, even if they were only able to cover one problem per day. Communication was a fundamental component of mathematical learning. Minor changes in classroom layout and instruction promoted discourse and allowed for changes on the way to a positive culture.

Discourse allows for a process that students can practice in a classroom. "Just as teachers' perceptions of their environments affect instruction, so too do students' perceptions" (Kilpatrick & Swafford, 2013, p. 332). Creating a positive culture with discourse allows students not to focus on the objective they are achieving (Bostic & Jacobbe, 2010). Identified guidelines for implementation include using related problems, facilitating reflection, scaffolding, focusing on sharing ideas, and supporting the needs of students implemented (Bostic & Jacobbe, 2010). Observable changes took place when this discourse for problem-solving was implemented. Students should be able to organize and consolidate their mathematical thinking through communication.

Like Bostic and Jacobbe (2010), Fernsten (2007), and Hufferd-Ackles, Fuson, and Sherin (2004), classroom environment, especially at the elementary level, is critical to allow this discourse community to take place. Students must consolidate their ideas and communicate them to their peers. Last, the reflection of one's practice is critical to improving mathematics instruction. Reflection of one's practice will lead to high-quality instruction for elementary and middle grades students. Visual representations are important in the mathematics classroom (NCTM, 2014). Visuals help students to advance understanding of mathematical concepts and procedures. Visuals help students make sense of problems and engage in mathematical discourse (NCTM, 2014). Students should communicate their mathematical thinking coherently; therefore, visual representations are beneficial.

In conclusion, to achieve high standards in mathematics education, teachers must follow clearly set goals. Teachers must be active participants in becoming the catalyst for reform mathematics. The NCTM sets the goals needed for improved and successful mathematics. Embedded within the NCTM principles and standards is a necessity for reform mathematics, including discourse and communications embedded in classrooms

(NCTM, 2000b). Students deserve and require the best mathematics education possible, one that enables them to fulfill personal goals and career goals in an ever-changing world. Equity requires high expectations and valuable opportunities for all. Last, "students who have opportunities, encouragement, and support for speaking, writing, reading, and listening in mathematics classes reap dual benefits: they communicate to learn mathematics, and they learn to communicate mathematically" (NCTM, 2000b, p. 57). Classrooms rich in discourse allow for divergent responses, multiple answers, multiple explanations, co-construction of meaning, and build on prior knowledge, participation, and deep rigorous mathematical thinking (Jabari, 2016; Larsen & Bartlo, 2009). Discourse-rich classrooms strategically articulate thinking, as opposed to a correct answer in the shortest time possible (Jabari, 2016). Creating a learning environment where students feel comfortable questioning themselves and others increases the learning opportunities (Carter, 2008). The process of learning, not answers, becomes the focus (Carter, 2008).

Learning Environment and Classroom Norms

A safe classroom environment allows students to take risks by presenting ideas and errors. All teachers and students respect the ideas and errors presented, and all classroom members listen to the discussion and critique ideas, not people. The learning environment should be supportive. For students to do mathematics, classrooms must contain environments where students are encouraged to engage in a rich mathematical activity (Henningsen & Stein, 1997). It is hard for some teachers to realize that the agenda is entirely relinquished to and driven by students, and their questions and responses. Student thinking should propel the discussions (De Garcia, 2011). In addition, teachers need to consider both the physical and emotional environment to establish a supportive environment and encourage discourse.

It is beneficial for students to face one another. De Garcia (2011) suggested a circle or semicircle. Students can sit on the floor or in chairs, which allows the teacher to sit with students to encourage peer-to-peer discussion. When students look at each other, they invite others to direct their comments to one another. De Garcia suggested the emotional environment should be safe. Teachers should ask students to think deeply about mathematics. The environment must have a sound basis with classroom norms, increasing respect and wait time (Chapin et al., 2009; De Garcia, 2011; Reinhart, 2000; Smith & Stein, 2011). Reinhart (2000) stated,

> If I always call on one of the first students who volunteers, I am cheating those who need more time to think about and process a response to, my question. Even very capable students can begin to doubt their abilities, and many eventually stop thinking about my questions altogether. (p. 480)

Waiting allows students the time to think and sets the expectation that someone will respond, and that the teacher will wait until someone does (De Garcia, 2011). Teachers should explicitly teach the social behaviors necessary to engage in discourse as a whole group, small group, or partners. Students can achieve social justice through classroom culture (Hung, 2015; Sammons, 2012).

Student's Role in Discourse

Knuth and Peressini (2001) depicted a framework of the separate roles of discourse. Students should understand the value of inquiring into one another's mathematical justifications and they should engage in mathematical discussions

(Gonzalez & DeJarnette, 2013). For discourse to occur efficiently, students must listen to and respond to the teacher and one another (NCTM, 2000b). Students must use a variety of tools and initiate problems and questions. Moreover, students should be trying to convince themselves and others of their method or solution (NCTM, 2000b). Students should constantly search for patterns and inconsistencies. In a discourse-rich classroom, students constantly build on each other's ideas. They are also constantly challenging and re-voicing their peers' ideas.

When students become active listeners, they learn to pay attention to the speaker and show they are listening via nonverbal and verbal cues. Teachers and students provide feedback to one another by asking questions and summarizing what the other is saying (Carter, 2008; Wagganer, 2015). Active listeners allow the speaker to finish before asking follow-up questions or giving opinions. All involved in active listening respond openly, honestly, and respectfully (Wagganer, 2015). In an ideal discourse-rich classroom, the "teacher serves a more peripheral role. Without prompting from the teacher, students question one another, explain and justify their ideas, and work together to compare strategies and solutions" (Hoffman, Breyfogle, & Dressler, 2009, p. 234).

The Teacher's Role in Discourse

According to the NCTM (2014), teachers use questioning effectively to "assess and advance student understanding, provide opportunities for productive struggle, and facilitate discourse to foster conceptual understanding and procedural fluency" (p. 114). Effective learning and teaching incorporate the ability of a teacher to facilitate meaningful mathematical discourse (NCTM, 2014). Before a productive mathematical discussion can occur, teachers first need to establish a clear and accurate goal of what is to be taught and learned (Smith & Stein, 2011). Orchestrating discussion “requires teachers to promote public displays of student thinking” without imposing or becoming authoritative in the conversation (Bahr & Bahr, 2017, p. 352). Teachers then encourage students to build on what they hear. Next, teachers should select a high-level mathematical task (Smith & Stein, 2011). Planning is an important metacognitive behavior; “it requires students to outline a solution before diving in” (Raymond, Gunter, & Conrady, 2018, p. 279). Moreover, the teachers must proactively and consistently support students' thinking without reducing the complexity of the task (Henningsen & Stein, 1997).

Per the NCTM (2014), learners need to have experiences that can enable them to construct knowledge socially through discourse and interaction related to significant problems. Simultaneously, the teacher should anticipate and respond to students. The teacher needs to “develop a deep knowledge of mathematical concepts and principles to understand the reasons behind students' errors” (Maguire & Neill, 2006, para. 17).

Similarly, the most important practice is to allow students to “build a shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments” (NCTM, 2014, p. 10). Planning for such tasks should be related to the Standards for Mathematical Practice. According to Mates (2016),

> The evidence of the Standards for Mathematical Practice is in student thinking, and the task is the site of interaction between students and mathematics; planning particular supports to help students use the mathematical practices must be done at this level. (p. 98)

Students must understand the teacher's rationale for discourse and students will not participate if their thoughts are ridiculed. The teacher should encourage a safe space for learning (Jabari, 2016).

In contrast to the beliefs of many researchers, teachers with productive beliefs understand the role of the teacher is to engage students in tasks that promote reasoning and problem solving through discourse (NCTM, 2014). Having productive beliefs allow for a shared understanding of mathematics (NCTM, 2014). The teacher's role is critical regarding how the discourse results in outcomes of student learning (NCTM, 2000b; Truxaw & DeFranco, 2007). Students "develop ownership and increase their understanding of mathematics when they can discuss alternative perspectives" (Gonzalez & DeJarnette, 2013, p. 544). By having students "talk about their informal strategies, teachers can help them become aware of, and build on, their implicit informal knowledge" (NCTM, 2000b, p. 21).

The questions teachers choose to ask are key to elicit discourse in a mathematics classroom (Gonzalez & DeJarnette, 2013). Teachers can incorporate phrases and questions, such as "Can you tell us more?," "Can you explain how . . . ?," "Can you explain why . . . ?," "Does that answer make sense?," and "Is it possible both answers are correct?" (Gonzalez & DeJarnette, 2013). Additionally, anticipating and monitoring are critical steps for the teacher to make the most use of students' thinking (Smith & Stein, 2011). The teacher should anticipate all the ways in which a student may solve a problem, as well as anticipate errors the student may make (Smith & Stein, 2011). Next, the teacher should consider questions to ask to help students in making progress towards understanding (Smith & Stein, 2011). Thereafter, making connections will aid in guaranteeing that key ideas are made apparent and public for students to make sense of mathematics (Smith & Stein, 2011). Questions that involve probing and exploring meaning and relationships push students toward explaining the why of their thinking and, in turn, the students discover mathematical reasoning (Smith & Stein, 2011).

Incorporating discourse allows teachers to build students' conceptual and procedural knowledge. “Targeted instruction to develop math talk strategies results in students who actively listen and constructively critique mathematical statements” (Wagganer, 2015, p. 253). Discourse also gives teachers valuable information regarding students' progress and aids in planning next steps in the classroom. While eliciting discussions, teachers should use a nonjudgmental tone. Student presentations of ideas should not be interrupted nor overlapped with teacher ideas. In conclusions, numerous ways exist for the teacher to encourage students to ask more questions, so the teacher is not the sole facilitator of the discourse. Although students work on a problem, “our role as instructors is to facilitate their explorations and offer guidance without giving the solution” (Kimani, Olanoff, & Masingila, 2016, p. 147).

Effective Questions

Teachers can promote discourse and stimulate students' thinking through effective questioning (Kimani et al., 2016). This process develops the mind-related habits for mathematicians suggested by the Standards for Mathematical Practice. The aim of effective questioning is to increase discourse and improve current discourse (Kimani et al., 2016). Teachers should increase open-ended questions and decrease close-ended questions. Closed-ended questions are those that can be answered with one word, whereas open-ended questions are those that require explanation. Good questions require more than recalling a fact (Reinhart, 2000). Along with open-ended questions, the teacher should use more process questions instead of product questions (Reinhart, 2000). These questions require students to think at higher levels (Reinhart, 2000).

Fermi questions are questions asked to encourage multiple approaches to solving and emphasize the process rather than the product ("Asking Questions and Promoting Discourse," 2017; Taggart et al., 2007). Fermi questions are named after a famous physicist, Enrico Fermi, and are used "to train his students' abilities to seek fast, rough estimates in situations where the available facts are incomplete or where a direct measurement seems to be difficult or impossible" (Posamentier, 2013, p. 7). Fermi questions also encourage nontraditional problem-solving strategies. For example, "you might ask your class, 'How many drops of water are in Lake Erie?' or 'How many balloons can fit in the school gym?'" ("Asking Questions and Promoting Discourse," 2017, para. 8). If a discussion becomes stagnant, teachers can pose questions to encourage further participation. One such question is, "would someone like to add on?" As the students share their thinking, the teacher asks questions to help students express themselves, understand others, and clarify thinking to make sense of the mathematics. Teachers should use questions strategically to engage students in mathematical discourse. Fermi questions support the NCTM's Principles and Standards for School Mathematics by fostering strong problem solving, reasoning, computational, and representational skills (Taggart et al., 2007).

Worthwhile Mathematical Tasks

The task a teacher chooses significantly influences students' thinking (Kimani et al., 2016; SanGiovanni, 2016). Procedural tasks in which teachers expect students to use algorithmic approaches are usually not good candidates for discourse. Interesting problems that have multiple entries and exit points mathematically can often be catalysts for rich conversations (Larsen & Bartlo, 2009) and maximize the instructional potential (SanGiovanni, 2016). Researchers in this field of mathematics education constantly recommend the exposure of students to meaningful and worthwhile mathematical tasks that are truly problematic, rather than students simply practicing algorithms (Stein, Groover, & Henningsen, 1996). Within effective teaching, "worthwhile mathematical tasks are used to introduce important mathematical ideas and to engage and challenge students intellectually. Well-chosen tasks can pique students' curiosity and draw them into mathematics" (NCTM, 2000b, p. 18). Conceptual understanding is developed when the task involves discourse to promote reasoning and problem solving (Michaels, O'Connor, & Resnick, 2007; NCTM, 2014; SanGiovanni, 2016).

Larsen and Bartlo (2009) suggested that worthwhile mathematical tasks meet certain guidelines. Suggested guidelines include tasks that provide multiple access points, tasks requiring the creation of a mathematical model, tasks with multiple justifiable approaches, and tasks that provide context to support the resolution of the argument (Figure 2; Boaler, 2016a; Larsen & Bartlo, 2009). Productive mathematical discussions are unlikely to occur if the task requires limited thinking and reasoning (Smith & Stein, 2011). Therefore, students begin to do mathematics by engaging in activities, such as questioning, challenging, and justifying (Kimani et al., 2016; Larsen & Bartlo, 2009; Stein et al., 1996). Rumsey and Langrall (2016) noted

> By having opportunities to confront such issues as being specific about the conditions of the numbers, critiquing the claims of others, and considering

unfamiliar claims confidently, the students gained a conceptual understanding of the arithmetic properties, rather than only a procedural understanding. (p. 419)

Henningsen and Stein (1997) advocated students "develop their sense of what it means to do mathematics from their actual experiences with mathematics, and their primary opportunities to experience mathematics as a discipline are seated in the classroom activities in which they engage" (p. 525). Larsen and Bartlo (2009) conducted a study for kindergarten to twelfth-grade in-service teachers, as part of the Oregon Mathematics Leadership Institutes, in which the researchers discerned tension created an intellectual need. For students to rid the voltage, they needed to stop relying exclusively on their intuition with the task. Students had to base their arguments more on class consensus, which evolved from intuitional and mathematical explorations (Larsen & Bartlo, 2009). Tasks relating to real-life situations help students to discover the problems of daily life with mathematical perspectives (Li & Ni, 2011). Figure 2 presents the relationship between the task sequence, discourse, and opportunities for learning.

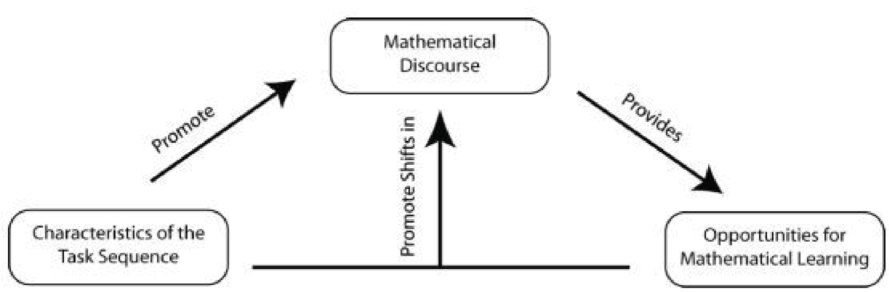

Figure 2. Discourse-Rich Mathematical Tasks

Figure 2 depicts an illustration of the interaction between tasks, mathematical discourse, and opportunities for mathematical learning. This figure is adapted from *The*

Role of Tasks in Promoting Discourse Supporting Mathematical Learning, (Larsen & Bartlo, 2009, p. 78).

Chapter III

METHODS

I determined the significance of group differences that teaching experience and education have on teachers' perceptions of univocal discourse, dialogic discourse, and general discourse. The study result allowed me to answer the following research questions: (1) Do years of teaching experience, educational status, and grade level range of instruction affect teachers' perceptions of univocal discourse usage? (2) Do years of teaching experience, educational status, and grade level range of instruction affect teachers' perceptions of dialogic discourse usage? (3) Do years of teaching experience, educational status, and grade level range of instruction affect teachers' perceptions of general discourse usage?

Within the methodology chapter, I define the research methods used to conduct the study. The chapter includes a description of the research design and an explanation of how I used the data to address the research questions. Each section presents reasons and justifications for the design, instruments, procedures, data collection, and statistical analysis.

Research Design and Rationale

This inquiry was original research following a survey design methodology. Additionally, I used the same survey instrument during six classroom observations to support or negate the findings of the teacher reported perceptions. I used a survey to collect the data required for analyses. A survey was appropriate because I sought to understand the current teachers' perceptions and practices of univocal, dialogic, and general discourses. Likewise, using Internet surveys allowed for scores of completed questionnaires to be collected in a brief period and with zero cost to me. E-mail surveys were low in cost and the turnaround was quick for data collection.

Population, Participants, and Setting

The target population for this survey research was kindergarten through eighth-grade teachers in the school system in a southeastern state. The complete population had 2,874 certified teachers in kindergarten through eighth grades, while the targeted sample had approximately 1,425 certified teachers. The sample for this study included certified elementary and middle-grade teachers. The targeted sample of certified kindergarten through eighth-grade teachers came from 19 schools serving elementary- and middle-grades students. The targeted population included certified teachers new to the profession as well as veteran teachers close to retirement. One school in the targeted population had only 18 teachers, while a much larger school had 125 teachers. The schools in the sample had a range of 40 teachers to 125 teachers. The school sizes in the sample were slightly smaller than the average school size in the population. The average sample school size had 75 teachers, and the average school in the targeted population had approximately 65 teachers.

I chose the participants for the six classroom observations based on convenience nonrandomized sampling. To be least intrusive, I chose teachers who were at schools which I have served longest. Often at my schools, grades third to fifth are departmentalized, therefore I chose two from the kindergarten through second grade level band, two from the third through fifth grade level band, and two middle grade classrooms to visit for the observations. When considering the classroom observations, it is important to consider these classroom observations lasted approximately 45 minutes each. These were unannounced, and teachers were following a district set pacing guide which mandates the specific content standards to work on for that week.

Sampling and Sampling Procedures

The sampling procedure was a nonrandomized selection process called convenience sampling. A school system in a southeastern state was comprised of 55 schools, and the schools were divided among four executive directors who were charged with school improvement. The sample for this research was the 19 schools under the charge of one out of four executive directors. One executive director covered specialized instruction and early childhood education, the second executive director covered elementary, kindergarten through eighth-grade governance, the third director was also elementary, and kindergarten through eighth-grade governance and the fourth director covered secondary governance (Figure 3).

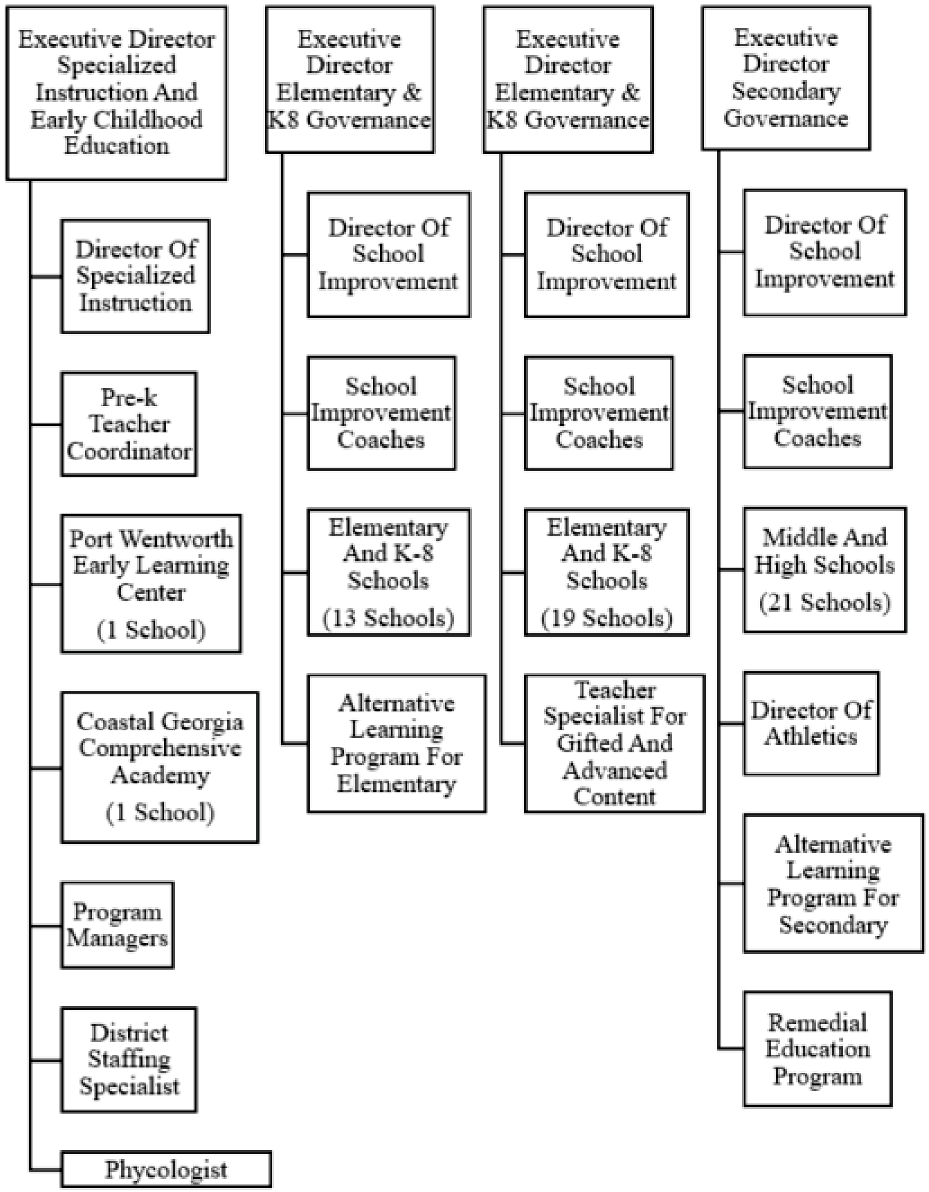

Figure 3. Academic Affairs Organizational Flowchart for Executive Director Tiers

Instrumentation and Operationalization of Constructs

The survey, originally created by Truxaw et al. (2008), measures kindergarten through eighth grades mathematics teachers' perceptions about discourse in mathematics classes. Initially in Truxaw et al.'s (2016) research, the question to be addressed was, “What are the factors underlying the perceptions of K–8 mathematics teachers about the use of discourse in their mathematics classes?” (Truxaw & DeFranco, 2008, p. 58). I gained permission to use the survey from Dr. Truxaw (Appendix B). I chose this survey because of the content relatability as well as the length and nature of the survey. Short surveys have a higher return rate over longer surveys.

The survey was divided into two sections. The first section solicited demographic information from respondents and included four items. Respondents were asked to select the grade level of their current teaching assignment—kindergarten to 2nd grades; 3rd to 5th grades; or 6th to 8th grades—and whether they currently taught mathematics (yes or no). The survey addressed years of teaching experience in item 3 with coded responses of 1 (*0 to 5 years*), 2 (*6 to 10 years*), 3 (*11 to 15 years*), and 4 (*more than 15 years*). The highest level of education pertained to responses coded as 1 (*Associate's Degree*), 2 (*Bachelor's Degree*), 3 (*Master's Degree*), and 4 (*Sixth Year / Specialist Degree and above*).

The second section included 18 ordered response items that addressed the respondents' frequency of occurrence for dialogic, univocal, and general discourse practices. Responses ranged from 1 (*Seldom/Never*) to 5 (*Almost Always*). Truxaw et al. (2008) suggested the univocal discourse questions include items 3, 6, 8, 10, 13, and 16; the questions about dialogic discourse are items 2, 4, 5, 9, 11, 12, 14, 15, and 18; and the questions about general discourse are items 1, 7, and 17. The survey then prompted respondents to contact me with any questions.

Validity and Reliability

Truxaw et al. (2008) tested the validity of the instrument. Validity represents whether the instrument measures what it was intended to measure. Truxaw et al. calculated descriptive statistics, including means, standard deviations, skewness, and kurtosis. “Fifteen of eighteen items tested normal for kurtosis” (Truxaw & DeFranco, 2008, p. 60). Mean responses were high (ranging from 3.19 to 4.57) and the data were somewhat negatively skewed; therefore, Truxaw et al. used factor analysis to further identify and verify the constructs.

Content Validity

Truxaw et al. (2008) used content validity questionnaires to assist sorting the items according to general, univocal, and dialogic discourse. Truxaw et al. addressed the content validity of the instrument using research literature. “Initial stems for the core items were linked to sources in the research literature that were relevant to the constructs of dialogic, univocal, and general discourse” (p. 60). Seven mathematics teacher experts, who focused their research on the topic of discourse, validated the content of the survey questions. Items with high inter-judge consistency were retained; items with low inter-judge consistency were eliminated. A second validity questionnaire was developed, and experts rated the appropriateness of each question stem. After two questionnaires, nine dialogic items, six univocal items, and three general items were included.

Construct Validity

In addition to content validity, Truxaw et al. tested the construct validity of the instrument. The experts tested construct validity using descriptive statistics, which included means, standard deviations, skewness, and kurtosis. Fifteen of the items were normal for kurtosis. The researchers verified these constructs using factor analysis to test for appropriateness.

Reliability

"Two internal consistency estimates of reliability were computed for the 18 core items of the questionnaire: coefficient alpha and split half coefficient expressed as a Spearman-Brown corrected correlation" (Truxaw et al., 2008, p. 61). "For the split-half coefficient, the scale was split into two halves such that the two halves would be as equivalent as possible. The split-half coefficient was .82 and the coefficient alpha was .85, indicating satisfactory reliability. These reliability coefficients indicate that the items can be considered a fairly homogenous set, possibly consisting of one or more individual components" (Truxaw et al., 2008, p. 61). Factor analysis revealed three reliable factors of the three types of discourse. The coefficient alphas for the three factors were .83 for dialogic discourse, .68 for general discourse, and .67 for univocal discourse.

Threats to Internal Validity

Because the study was proposed to describe group differences, internal validity had a minimal effect on the results. Fraenkel and Wallen (2009) defined internal validity as the extent to which observed differences on the dependent variable are directly connected to the independent variable, not to some other uncontrolled variable. According to Fraenkel and Wallen, four threats to internal validity exist: "mortality, location, instrumentation, and instrument decay" (p. 404). This study was not longitudinal; therefore, the threat of mortality small or nonexistent. This study may become weaker because of the location threat of internal validity. I administered this survey to teachers in a school setting, which may affect responses. It was likely; however, that teachers were comfortable in their classroom setting and the location threat was not a viable internal validity threat. Instrument decay was not likely because there were no interviews that took place. Interview decay occurs when the interviewees feel tired or rushed (Fraenkel & Wallen, 2009).

To minimize threats to internal validity, I standardized the conditions to the survey. All participants received the same e-mail with the same link at the same time. Because the sample participants were under the same executive director, this helped eliminate any subject characteristics that allowed participants to differ from one another in unintended ways.

Because "teacher perceptions can be affected by how they perceive that the data will be used" (Maulana & Helms-Lorenz, 2016, p. 337), I added a classroom observation component to support or refute the findings from the teacher self-reported surveys. I used the same instrument for the classroom observations that was used for the anonymous teacher perception survey. Teachers may respond to surveys in a more socially accepted way than the real practice reveals. According to Creswell (2014), "triangulation or multiple methods of data collection and analysis will be used, which strengthens reliability as well as internal validity" (p. 260).

Procedures

I e-mailed the survey link to administrators of the 19 schools, who then forwarded the link to the teachers during data collection week one. The rationale for this was because "a higher response rate can be obtained if a questionnaire was sent to persons in authority to administer to the potential respondents rather than sending it to the respondents themselves" (Fraenkel & Wallen, 2009, p. 395). After this initial contact with administrators, I sent two weekly follow-up reminder e-mails with a link to the Qualtrics survey to the certified staff of the 19 schools (Appendices E and F). After the data collection was completed, I exported the raw data from Qualtrics to SPSS for the data analysis portion of the research.

Participation, Data Collection (Primary Data), and Management

Prior to data collection, I obtained Institutional Review Board (IRB) approval to conduct the study. The participants received the informed consent in the body of the e-mail they received with the survey link (Appendix D). Because Internet surveys are not intrusive and private, I collected disseminated data using Qualtrics, a web-based application commonly used at my university (Appendix C). Participants exited the study upon completion of the survey or at any time by independently choosing to exit the browser window.

I selected “anonymize response” so that Qualtrics does not record any personal information and removed contact association. Using Qualtrics allowed the data to be easily exported to Microsoft Excel and then into SPSS. Participants viewed and answered survey questions using a web browser on a personal or school-based computer or a mobile device.

By allowing participants to answer the survey questions on a survey online, they remained anonymous and respondents were encouraged to answer truthfully with confidence that their answers are anonymous. The data received through Qualtrics, was basic demographic information (Appendix C) and critical information for the research. I kept the information private through a locked Valdosta State University Qualtrics account. Only I was able to access the data.

I chose to use a more secure site (Qualtrics) as opposed to using a Google Forms to collect survey data. Using Qualtrics allowed the research not to lose credibility because of confidential information being exposed. Search engines, such as Google, allow for exploration of all linked content and thus hackers can easily collect data. Using Qualtrics allowed me to password protect the data for extra security.

During the data collection window, I also used the same tool to conduct classroom observations. Teachers often exaggerate their own teaching behavior and frequently "underestimate their judgments regarding negative teaching behavior," therefore I added the data source of classroom observations (Maulana & Helms-Lorenz, 2016, p. 337). I conducted three observations at the kindergarten to the second-grade level range, three at the third to the fifth-grade level range, and three at the sixth to the eighth-grade level range. Because teachers self-reported their perceptions of discourse, I used observations to offer a second data source. The purpose of adding the observation component was to crosscheck the results from the survey. "Results from self-report survey data should be interpreted with care and should not be over-extrapolated" (Maulana & Helms-Lorenz, 2016, p. 337).

Data Analysis

Descriptive Statistics

I used Statistical Package for the Social Sciences (SPSS) to aid with statistical analyses. Respondents and non-respondents were reported. I reported response rate as a total percentage of those surveyed out of the sample size. The first portion of data analysis was the demographic information. Specifically, the number of participants of the sample, the table displaying the number of respondents for each grade level range, the number of respondents who currently teach mathematics, and the number of respondents for each group of teaching experience and educational level. A table presented this information.

In the second portion of data analysis, I presented descriptive statistics for each survey item. I reported the mean and standards deviations for each survey item in a table. Additionally, I reported the mean and standard deviation for the total univocal, dialogic, and general discourse items.

Study Variables

I used Cronbach's alpha to measure the internal consistency of the three factors of discourse (Fraenkel & Wallen, 2009) prior to summing across items. If the result of the Cronbach's alpha statistical test was not at least alpha = .65, the instrument may not be sufficient to detect a relationship (Fraenkel & Wallen, 2009). If the alpha was higher than or equal to .65, the items associated with the factor were summed across to create the dependent variables, univocal, dialogic, and general discourse.

Prior to running an ANOVA, I addressed several assumptions. These assumptions include interval data of the dependent variables, normality, and homogeneity of variance for consistency (Statistics Solutions, n.d.). I checked for normality using a histogram with a normal distribution curve. The Levene's test allowed me to test the homogeneity of variance. The dependent variables were continuous, and the total score was used for each type of discourse. The interval measurement scale points ranged from three to 15 for general discourse, 6 to 30 for univocal discourse, and 9 to 45 for dialogic discourse. Factorial ANOVAs can only incorporate categorical independent variables, and the three independent variables were educational level, years of experience, and grade level range of instruction.

I applied a factorial ANOVA to determine any differences in teacher perceptions of discourse usage. Factorial ANOVAs tested for mean differences in the two main effects. An additional benefit of using factorial ANOVA, in this case, was that it revealed whether the combination of teaching experience and education level have an interactive effect on teachers' perceptions of univocal, dialogic, and general discourse.

Last, I used the data collected from the classroom observations to support the generalizability of the information gathered from the quantitative data analysis. The observation component was used to link information regarding teacher perceptions and teacher behavior. The classroom observations were unscheduled, brief, and conducted during mathematics lessons of the appropriately corresponding grade level range (Grades K–2, Grades 3–5, and Grades 6–8).

Ethical Procedures and Anticipated Ethical Issues in the Study

To avoid any ethical issues, the participants in the study remained anonymous other than the demographic information given in the survey. According to Creswell (2014), "ethical questions are apparent today on such issues as personal disclosure, authenticity, and credibility of the research report; the role of researchers in cross-cultural contexts; and matters of personal privacy through forms of Internet data collection" (p. 132). By allowing participants to answer the survey questions through a survey online, they remained anonymous and were encouraged to answer truthfully with confidence that their answers are anonymous. I followed Institutional Review Board (IRB) recommendations before conducting research.

I set Qualtrics parameters to allow participants to skip questions, and did not require a name, e-mail address, or physical address. I downloaded data for research purposes and stored it in Dropbox for educational use. The process of downloading the data was for statistical purposes to upload into SPSS. Data were stored on the Qualtrics platform only while I had access to the Valdosta State University Qualtrics database. Qualtrics' servers are “protected by high-end firewall systems and scans are performed regularly to ensure that any vulnerabilities are quickly found and patched” (Qualtrics, 2017, para. 3). Only I had access to the data. Data were disseminated through the final findings in this study. Raw data were not available for access.

Participants were not exposed to any physical or psychological harm, stress, or embarrassment. This research does not violate any of the code of ethics for educators as presented by the Georgia Professional Standards Commission (Georgia Professional Standards Commission, 2013). According to the Georgia, Professional Standards Commission (2013),

> The Code of Ethics for Educators defines the professional behavior of educators in Georgia and serves as a guide to ethical conduct. The Georgia Professional Standards Commission has adopted standards that represent the conduct generally accepted by the education profession. (para. 1)

Summary

The researcher included in Chapter 3 the research design, participants and setting, instrumentation, procedures, data collection and management, data analysis, and anticipated ethical issues in the study. Chapter 4 contains the research findings organized by research question and hypotheses. Last, Chapter 5 includes the conclusions, discussions, and suggestions for future studies.

Chapter IV

RESEARCH FINDINGS

The NCTM (2014) recommends communication and dialogic discourse to support student achievement and higher order thinking skills since both are essential to building mathematical understanding. The goal of this study was to assess teachers' perceptions of univocal discourse, dialogic discourse, and general discourse. In addition, differences due to experience, grade, and educational level were explored. The following research questions were addressed: (1) Do years of teaching experience, educational status, and grade level band of instruction affect teachers' perceptions of univocal discourse usage?, (2) Do years of teaching experience, educational status, and grade level band of instruction affect teachers' perceptions of dialogic discourse usage?, and (3) Do years of teaching experience, educational status, and grade level band of instruction affect teachers' perceptions of general discourse usage?

Chapter 4 includes instrumentation, data collection, a description of the participants and study variables. Additionally, data screening, study results, and a summary of the research findings are presented.

Participants

The sample schools for this research included the 19 schools under the charge of one executive director. The target population for this study was 2,874 teachers with a sample size of 1,425. The survey was sent to the sample of 1,425 teachers. Of the sample, 337 responded to the survey, with a response rate of 23.64 percent. Participants who responded with incomplete surveys, and those who did not teach math were removed from analysis. In total, 213 completed surveys were recorded and used for data analysis.

Participating teacher demographics are presented in Table 2. Participants primarily taught elementary grade levels and a majority had 11 or more years of teaching experience. Of those who responded, 139 (65.30 percent) had a master's degree or above.

Table 2

Frequencies of Subgroups of Participants

		Frequency	Percent
Grade Level	Elementary	193	90.6
	Middle	20	9.4
	Total	213	100.0
Experience Level	0-10 Years of Experience	87	40.8
	11+ Years of Experience	126	59.2
	Total	213	100.0
Degree	Associate's or Bachelor's Degree	74	34.7
	Master's Degree or Higher	139	65.3
	Total	213	100.0

Instrumentation

A survey was employed to measure teachers' perceptions of discourse usage in their classrooms. This survey consisted of 18 items. The scale had a high level of internal consistency reliability as determined by a Cronbach's alpha. The Cronbach's alpha is .90, which indicates an excellent level of internal consistency reliability for the scale with this specific sample.

Cronbach's alpha is the most common measure of internal consistency. Table 3 presents the value that the Cronbach's alpha would be if that item were deleted from the scale. If the third survey item were removed, there would be a small improvement in the

Cronbach's alpha for the survey. Cronbach's alpha provides an overall reliability coefficient for a set of variables. However, I chose to leave this item in the survey for calculating the results due to the limited number of general discourse survey items (Table 3).

Table 3

Item Total Statistics

In my mathematics class (es) . . .	Cronbach's Alpha if Item Deleted
I encourage discussion.	0.90
Verbal communication is an important part of learning	0.90
All students participate in discussions.	0.91
I ask students to justify their mathematical ideas.	0.89
Students, lead mathematical discussions.	0.90
Discussions help students to generate their own meaning of mathematical topics.	0.90
Learning involves the negotiation of mathematical meanings.	0.90
I ask students to explain their mathematical ideas.	0.89
Discussions help students analyze problem-solving strategies.	0.90
I follow up student responses by probing for understanding.	0.89
I ask students for alternative strategies.	0.90
I ask students to elaborate verbally on their mathematical ideas.	0.89
I verbally assess students' responses.	0.89
Communication is used to convey exact ideas to students.	0.90
I evaluate the correctness of students' responses.	0.90
Discussions encourage students to replicate procedures precisely.	0.90
Discussions are geared toward informing students about mathematical procedures.	0.90
I ask students to repeat the steps of mathematical procedures verbally.	0.90

Study Variables

The dependent variables for this research were total sum scores for the survey items for univocal discourse, dialogic discourse, and for general discourse. The dependent variables were continuous on an interval measurement scale from 3 to 15 (*general discourse*), 6 to 30 (*univocal discourse*), and 9 to 45 (*dialogic discourse*). Cronbach's alpha was computed to measure the internal consistency reliability of each subscale. One construct, general discourse, consisted of three questions. The Cronbach's alpha was .59. A second construct, dialogic discourse, had nine items with a computed Cronbach's alpha was .88, which indicated a good level of internal consistency reliability. The third construct, univocal discourse had six survey items. The Cronbach's alpha was .84, which also indicated a good level of internal consistency reliability. Item descriptive statistics are presented in Table 4.

Table 4

Descriptive Statistics for Subscales

	M	*SD*	Number of Items
General	12.15	1.90	3
Dialogic	35.08	5.60	9
Univocal	23.58	3.99	6

Data Collection and Management

The output, code, and data analysis for this study were generated using Qualtrics software, Version 2017. Qualtrics and all other Qualtrics product or service names are registered trademarks of Qualtrics, Provo, UT, USA. http://www.qualtrics.com. I exported the raw data from Qualtrics to SPSS for data analysis.

Prior to data analysis, I chose to recode and deselect specific data variables and cases. Since there were so many categories and such a relatively small response rate, I recoded grade levels from three categories into two (elementary and middle-grade bands). I also recoded years of experience from four categories into two (0-10 years and 11+ years of experience). Additionally, I recoded the degree of the respondent from four categories into two categories (associate's/bachelor's degree and master's degree/+). I chose to eliminate all cases with missing values and all cases for which the respondents did not teach mathematics. I also omitted grade band from factorial ANOVA models because there were a limited number of middle school respondents (n = 20).

Data Screening

The dependent variables were assessed for adherence to the assumptions of normality and homogeneity of variance prior to analysis. In addition, data were screened for outliers by each subgroup. Outliers were assessed by inspection of histograms and box plots, normality was assessed using Shapiro-Wilk's normality test for each cell of the design and homogeneity of variances was assessed by Levene's test.

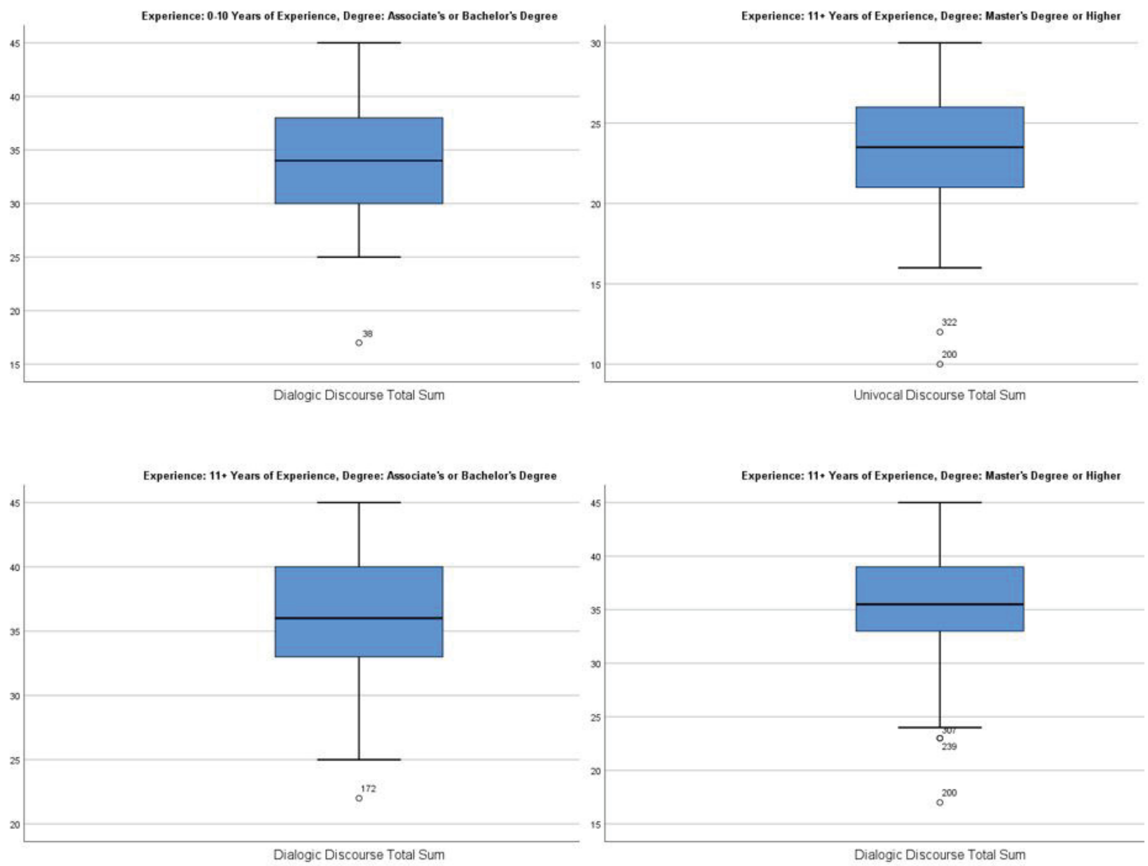

Figure 4. There should be no significant outliers in any cell of the design

A few outliers were noted in the boxplots, however, I decided to include the outliers in the analysis (Figure 4). The outliers were mostly within the dialogic discourse subscale, which had a larger range of scores since it had the highest number of questions.

Teacher perception scores were approximately normally distributed for years of teaching experience and education level as assessed by visual inspection of their histograms.

General discourse scores were normally distributed with a skewness of -.43 (*SD* = 1.89) and kurtosis of -.35. Dialogic discourse scores were normally distributed with a skewness of -.55 (*SD* = 5.60) and kurtosis of .26. Univocal discourse scores were normally distributed with a skewness of -.41 (*SD* = 3.99) and kurtosis of -.03.

Additionally, normality was assessed using Shapiro-Wilk's normality test for each cell of the design. Overall, data were normally distributed for general discourse, dialogic discourse, and univocal discourse, as assessed by Shapiro-Wilk's test. Grade level was removed from the normality tests because there were a small number of middle-grade participants (n = 20) (Table 5). Data were not normally distributed, as assessed by Shapiro-Wilk's test for some cases (Table 5).

Table 5

Tests of Normality for Total Sum Scores for the Dependent Variables

Experience	Degree	Shapiro-Wilk			
		Discourse Type	Statistic	df	Sig.
0-10 Years of Experience	Associate's or Bachelor's Degree	Univocal	.95	42	.08
		General	.95	42	.08
		Dialogic	.97	42	.36
	Master's Degree or Higher	Univocal	.96	45	.10
		General	.93	45	.01
		Dialogic	.98	45	.52
11+ Years of Experience	Associate's or Bachelor's Degree	Univocal	.97	32	.48
		General	.92	32	.02
		Dialogic	.96	32	.29
	Master's Degree or Higher	Univocal	.97	94	.02
		General	.95	94	.00
		Dialogic	.96	94	.01

The assumption of homogeneity of variances was met for all group combinations of teaching experience and educational level, as assessed by Levene's test. The results of Levene's tests were not significant indicating that the assumption of homogeneity of variance was met (Table 6).

Table 6

Levene's Test of Equality of Error Variances (Based on Mean)

	Levene Statistic	df1	df2	Sig.
General Discourse	.80	3	209	.50
Dialogic Discourse	.68	3	209	.57
Univocal Discourse	.61	3	209	.61

Two-way ANOVA procedures were used to assess the interaction effect and main effects for two of the three independent variables. Grade level was removed from the ANOVA tests because there were a small number of middle-grade participants (n = 20). To address grade level for each discourse type, three independent samples t-tests were run.

Results of Statistical Analyses

Descriptive statistics were calculated for total sum scores for dialogic discourse, general discourse, and univocal discourse total sum scores. The dialogic discourse sum had the highest mean score (M = 35.08, SD = 5.60). The general discourse sum had the lowest mean score (M = 12.15, SD = 1.89).

Three two-way ANOVAs were conducted to determine the effects of teaching experience and educational level on teachers' perceptions of univocal discourse, dialogic discourse, and general discourse total sum scores. Grade level was assessed using three independent samples t-tests. Results of the analyses are presented by research question.

Research Question 1

Do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of **univocal** discourse usage? The interaction effect between teaching experience and level of education on univocal discourse was not statistically significant, $F(1, 209) = .04$, $p = .84$. There was no statistically significant main effect for teaching experience, $F(1, 209) = .83$, $p = .36$. There was no statistically significant main effect for degree level, $F(1, 209) = .77$, $p = .38$. An independent-samples *t*-test between grade level bands (elementary and middle grades) found no significant difference in teachers' perceptions of univocal discourse, $t(211) = -.61$, $p = .54$.

Research Question 2

Do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of **dialogic** discourse usage? The interaction effect between teaching experience and level of education on dialogic discourse was not statistically significant, $F(1, 209) = .38$, $p = .54$. There was a statistically significant main effect for teaching experience, $F(1, 209) = 4.24$, $p = .04$. Teachers with 11 or more years of experience had a dialogic discourse score ($M = 35.85$, $SD = 5.30$) that was significantly higher on average than teachers with 0 to 10 years of experience ($M = 34.14$, $SD = 5.93$). There was no statistically significant main effect for degree level, $F(1, 209) < .001$, $p = .99$. An independent-samples *t*-test was run to determine if there were differences in teachers' perceptions of dialogic discourse between grade level bands (elementary and middle grades). A statistically significant difference was found $t(211) = -2.48$, $p = .01$. The mean of the elementary group ($M = 34.78$, $SD = 5.65$) was significantly lower than the mean of the middle grade level band group ($M = 38.00$, $SD = 4.15$).

Research Question 3

Do years of teaching experience, educational status, and grade of instruction affect teachers' perceptions of **general** discourse usage? The interaction effect between teaching experience and level of education on general discourse was not statistically significant, $F(1, 209) = 3.54$, $p = .06$. There was a statistically significant main effect for teaching experience, $F(1, 209) = 5.12$, $p = .02$. Teachers with 11 or more years of experience had a general discourse score ($M = 12.46$, $SD = 1.76$) that was higher on average than teachers with 0 to 10 years of teaching experience ($M = 11.83$, $SD = 2.05$). There was no statistically significant main effect for degree level, $F(1, 209) = .23$, $p = .63$. An independent-samples t-test was run to determine if there were differences in teachers' perceptions of general discourse between grade level bands (elementary and middle grades). No significant difference was found $t(211) = .12$, $p = .90$.

Additional Findings

I used classroom observations as an additional data source (Table 7). I conducted four observations in the elementary grade level bands and two observations in the middle grades. Of these observations, three teachers had 0 to 10 years of experience while the other three had 11 or more years of experience. Two of the six teachers had an associates or bachelor's degree while four of the classroom observation teachers had a master's degree or higher.

The univocal discourse total sum for the six classroom observations had the lowest standard deviation ($SD = 1.75$), while the dialogic discourse total sum for the classroom observations had the largest standard deviation ($SD = 6.09$) (Table 7). Classroom observations had similar standard deviations to those noted in the teachers' perception survey data.

Table 7

Descriptive Statistics for Classroom Observations (n = 6)

	Range	*Min*	*Max*	*M*	*SD*
General Discourse	5	7	12	9.83	2.14
Univocal Discourse	5	13	18	15.67	1.75
Dialogic Discourse	14	20	34	27.50	6.09

Classroom Observations

One of the middle-grade classrooms (seventh-grade) was working on interpreting graphs of proportional relationships. Within this activity, students were asked questions such as “why” or “why not” by the teacher when asked to explain the amount of flour used to bake a specified number of cookies. Students were doing this activity independently at the beginning of the lesson. They were working towards comparing and analyzing others work with a partner. This shows a shift from working independently towards peer-to-peer dialogic discourse. The teacher was using basic probing questions to begin discussion such as “What quantity is measured along the horizontal axis?” and “What quantity is measured along the vertical axis?” Both are simple questions, which do not encourage discussion. Both questions are close with one correct answer. One question used, which did encourage discussion in this classroom lesson, was when the teacher asked the students “How do you determine the meaning of any point on a graph that represents two quantities that are proportional to each other?” The standards required in this lesson lend themselves to the teacher asking Depth of Knowledge questions at the level one or level two. The standard for the lesson involving word problems, however, leads itself to the Depth of Knowledge Levels 1, 2, and 3 type questions. Higher-level questions tend to produce deeper levels of knowledge (Marzano et al., 2001).

One of the elementary grade level teachers was having her students find related multiplication facts by adding and subtracting equal groups in array models. Students were using arrays to decompose unknown facts as the sum or difference of two unknown facts. This idea builds on students' natural ability to work with part-whole relationships that they have been using in kindergarten, firsts, and second grades. The standards the students were working on were in the operations and algebraic thinking domain. These standards center on the work with third graders representing and solving problems involving multiplication and division. Students are to interpret products and quotients of whole numbers. Both standards lend themselves to Levels 1 and 2 Depth of Knowledge questions. This teacher could have easily added some dialogic discourse into her lesson by asking the students to analyze the strategies in pairs and present their thinking to the class during the debrief at the end of the lesson. This work is foundational to the distributive property. This was the classroom which the researcher scored highest in univocal discourse as well as low in dialogic and general discourse.

Additionally, another teacher in the elementary grade level band (third grade) was working on a similar lesson. This teacher was modeling the distributive property with arrays to decompose numbers as a strategy to multiply. This classroom was a special education classroom and had two teachers in the room. The lesson began pictorially which was beneficial to the students however, some students may have benefited from starting at the concrete level using manipulatives to build their arrays. Linking cubes or centimeter cubes would have easily been valuable for student use. Since this is the beginning of students' work with the distributive property, they begin with informal language using the terms “break apart and distribute”. The questions the two teachers were asking involved some peer-to-peer discussion. At several points in the lesson, students turned to their tablemates and discussed if their distributive property resulted in the same solution (practicing where parentheses were in each expression).

In another elementary classroom, students were working on place value understanding to round multi-digit numbers to any place. This standard lends itself to a Depth of Knowledge questions that are at the Level 1. This content simply suggests students will recall facts or rote application of simple procedures. Rounding is one strategy to produce a computational estimate. The teacher was allowing students explain their ideas one at a time. She was probing other students by asking, “What do you think?” She was encouraging children and asking more questions to assess understanding. One question this teacher could have asked to encourage more dialogic discourse for this lesson on rounding would have been “How does knowing how to round mentally assist you in everyday life?” Even though this standard did not lend itself to discourse, this was one of the two classrooms, which the researcher ranked as having the most general discourse.

Students in one classroom (first-grade) were working on addition word problems. The questioning in this lesson, where students were solving math stories in addition where the result is unknown, was primarily univocal in nature. One example of a question was “How many cans were there at the end of each day?” This question had one correct answer and ended the conversation before moving on to another example. The teacher could have encouraged dialogic discourse by asking “what do you notice about what happened each day?” or “If this pattern continues, how many cans will the class have on Friday?” Students could communicate once with their peers during the application problem they started together. They were prompted to notice similarities and differences in what they did for their drawings to solve the problem. This is an appropriate peer-to-peer dialogic discourse for a first-grade student. "When teachers use classroom talk a great deal, it gives students a chance to learn about respect and kindness. They learn that it takes time to understand somebody else's reasoning and that they have to be patient as others struggle to clarify."

Lastly, the researcher visited an eighth-grade classroom. Students were working operations with a number, which were written in scientific notation. The standards in this lesson lend themselves to levels one and two types of questioning according to a Depth of Knowledge level. Students learn to operate with numbers in scientific notation by making numbers have the same magnitude. One problem, involving authenticity to the students, was about the world population. The teacher asked the student about how many ants were in the world. The students were given the number 4.6×10^7 ants for every human on the planet. They were also told the population is seven billion. While this problem was exciting for the students, there was no discussion. Everything in this example was teacher-led. Students then completed another example (also teacher-led) and then were given time to do two problems on their own. After students worked the two problems on their own, the teacher gave them time to discuss with their partners. They were not given specific questions to answer but the teacher did move around the room and ask questions to individual partner pairs. This was one of the teachers the researcher ranked high in general and dialogic discourse.

Summary

There were two statistically significant main effects. There was a significant main effect for teaching experience on teachers' perceptions of general discourse as well as teaching experience on teachers' perceptions of dialogic discourse. Findings will be further discussed in Chapter 5. Additionally, Chapter 5 will highlight the summary of the findings, classroom observations, limitations of the study, as well as recommendations for future research.

Chapter V

CONCLUSIONS, DISCUSSIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

A teacher's disposition toward mathematics may influence his or her classroom dialogue and, as a result, how mathematics is taught and learned (Truxaw & DeFranco, 2007). Effective Mathematics teaching calls for a deep commitment to the development of students' understanding of mathematics (NCTM, 2000b; NCTM, 2014). The problem is that mathematics classrooms focus on the content standards with slight emphasis on the process standards (Boaler, 2015; McGatha & Bay-Williams, 2013).

The goal of this study was to assess group differences in teachers' perceptions of univocal, dialogic, and general discourse. In addition, differences due to the level of experience and education were explored. Results of this research provide a helpful step toward enhancing teaching practices. This research offers teachers an opportunity to understand current practices and encourage positive social change. One of the most powerful ways to raise student achievement is through professional learning and teachers' understanding of effective instructional practices (DuFour & Mattos, 2013).

This research allowed me to gain a better understanding of teachers' perceptions of discourse usage in their classrooms. This study directly impacts a social change because students who do well with discourse in mathematics also have more refined communication skills in life (McGraw-Hill Education, 2018). Additionally, students who do well with discourse have improved thinking skills (McGraw-Hill Education, 2018). When students participate in classroom discourse, they improve their communication and thinking abilities which impacts other content areas (McGraw-Hill Education, 2018). This study allows for district employees to better make decisions about upcoming curriculum choices. Curriculum should represent the most important skills that schools want their students to acquire. Discourse is one of these life skills (McGraw-Hill Education, 2018). Likewise, instructional methods should be appropriate for such curriculum.

Summary of the Findings and Conclusions

The following summary and conclusions are based a survey design with foundations from Truxaw, Gorgievski, and DeFranco's (2008) instrument on classroom discourse usage. In total, 213 completed surveys were recorded and used for data analysis. Additionally, six classroom observations were used to support or refute survey data. Both factorial ANOVA procedures and t-tests were used.

Summary of the Survey

I used three factorial ANOVA procedures to assess the effect of teaching experience and educational status on teachers' perceptions of general, univocal, and dialogic discourse usage. There were two statistically significant main effects. The first main effect finding was a statistically significant main effect of teaching experience on teachers' perceptions of general discourse usage. The second main effect finding was a statistically significant main effect of teachers' perceptions of dialogic discourse usage.

Finding 1. For the dialogic discourse subscale, teachers with 11 or more years of experience (M = 35.85, SD = 5.30) scored higher, on average, than teachers with 0 to 10 years of teaching experience (M = 34.14, SD = 5.93), $F(1,209) = 4.24$, $p = .04$.

The largest spread of responses came from the survey respondents' perceptions of dialogic discourse (*SD* = 5.60). For dialogic discourse, the classroom observations refuted the survey results. For the classroom observation component, I had higher scores for those with 0 to 10 years of experience than those with 11 or more years of experience. Survey results indicated teachers with 11 or more years of experience (*M* = 35.85, *SD* = 5.30) perceived a higher dialogic discourse score than those with 0 to 10 years of experience (*M* = 34.14, *SD* = 5.93).

Finding 2. Teachers with 11 or more years of experience (*M* = 12.46, *SD* = 1.76) scored higher, on average, than teachers with 0 to 10 years of teaching experience (*M* = 11.83, *SD* = 2.05) on the general discourse subscale, $F(1,209) = 5.20$, $p = .02$.

The general discourse perception total sum scores had the smallest spread (*SD* = 1.89). For general discourse, observation results refuted the self-reported survey results. For those with 0 to 10 years of experience, the classroom observation general discourse score was lower than the survey score (*M* = 11.83, *SD* = 2.05). Additionally, those with 11 or more years of experience ranked their general discourse survey score (*M* = 12.46, *SD* = 1.76) higher than me during the classroom observations.

Of the six classroom observations I conducted, one elementary teacher with 11 or more years of experience who had an associates or bachelor's degree had the highest total general discourse sum score on her general discourse during my classroom observation. This teacher had a general discourse total score close to the survey responses for teachers with 11 or more years of experience with the same level of education. Her total general discourse sum score came from the total of the three general discourse items on my classroom observation instrument. During my classroom observations, the elementary teachers with 11 or more years of experience having a master's degree or higher had the lowest ratings from me of their perceptions of general discourse.

Conclusions from the Survey

Finding 1. For the dialogic discourse subscale, teachers with 11 or more years of experience (M = 35.85, SD = 5.30) scored higher, on average, than teachers with 0 to 10 years of teaching experience (M = 34.14, SD = 5.93), $F(1,209) = 4.24$, $p = .04$.

Teachers with more experience (11 or more years) scored higher for dialogic discourse than teachers with less experience (0 to 10 years). One reason for this finding is that experienced teachers may naturally become better at asking more questions. Results of one study showed differences among the beginning and experienced teacher participants in the frequency and variety of questions asked (McAninch, 2015). The research of McAninch (2015) supports that after analyzing transcripts, she noted experienced teachers both more frequently asked questions as well as gave more feedback than novice teachers.

In my survey research, for both dialogic discourse and general discourse, teachers with more experience had higher perceptions of those types of discourse. This result may have occurred because more experienced teachers likely have their classroom management under control and are willing to take a risk on opening up the classroom discussion. Additionally, this may have occurred because teachers with more experience may have been teaching the same grade level for longer and would then have studied the mathematics content of that grade level longer as was also demonstrated in Jansen's (2009) study. I recommend teachers with 0 to 10 years of experience seek professional development to increase their familiarity of benefits of dialogic discourse and discussions in the mathematics classroom. Furthermore, novice teachers should be provided with opportunities to develop their conceptual understanding of mathematics knowledge for teaching (Jansen, 2009).

Finding 2. Teachers with 11 or more years of experience (M = 12.46, SD = 1.76) also scored higher, on average, than teachers with 0 to 10 years of teaching experience (M = 11.83, SD = 2.05) on the general discourse subscale, $F(1,209) = 5.20$, $p = .02$.

The survey results suggested that teachers with 0 to 10 years of experience scored their perceptions of general discourse lower than their more experienced peers. Research of Hufferd-Ackles et al. (2004) refutes this idea, saying that novice and experienced teachers alike have the ability to create working math-talk communities which encourage discourse. Based on the survey finding, I recommend teachers with 0 to 10 years of experience work towards building a community which welcomes student involvement as supported by Hufferd-Ackles et al. (2004).

Summary of the Classroom Observations

Classroom observations were utilized to triangulate survey data. Throughout my six classroom observations, three main findings became evident to me. The first main finding was the teachers were the primary ones asking the questions while the students were consumers of mathematics. The second main finding was the teachers had a fixed mindset about teaching mathematics and need to shift from univocal to dialogic discourse. The third main finding is that teachers must anticipate and plan for student responses to be prepared for classroom discourse.

Finding 1. The teacher was the primary person asking questions while the students were consumers of mathematics. The teachers in the classroom observations were using questioning, but more of the questions were univocal in nature, and less dialogic in nature. In four of the six classroom observations, the teacher was telling and showing students how to do math. I observed most of the talk in the classroom observations consisted of the teacher lecturing, asking students to recite, or posing simple questions with known answers. My findings align with the research of Anderson, Chapin, and O'Connor (2011) who also found benefits when students discuss and explore mathematical ideas. I observed most of the questions in the classroom observations were simple questions with known answers. In all six classroom observations, the teacher was the only questioner, asking short frequent questions to keep the attention of the students. Aligned with the classroom observations I conducted, Leatham, Peterson, Stockero, and Van Zoest (2015) agree it is critical for our teachers to value and support the shift from univocal to dialogic discourse.

Finding 2. Teachers have a fixed mindset about teaching mathematics and teachers need to shift from univocal to dialogic discourse. In my district, more work is to be done to shift the mindset of teachers to change their perceptions of dialogic discourse. This is supported by research in *Mathematical Mindsets* (Boaler, 2016a). Unfortunately, the fixed mindset appears to be more prevalent in mathematics than in other subject areas (Boaler, 2016a). Boaler (2016a) describes the importance of creating a risk in the classroom. She also notes mistakes strengthen perseverance.

Finding 3. Teachers must anticipate student responses. During my classroom observations, I did not see a teacher anticipate student responses. One teacher missed a valuable opportunity for classroom discourse by ignoring a student response, which was mathematically correct. Students' comments in class are largely representative of their current understanding or misconceptions, therefore it is critical for teachers to anticipate student responses.

Conclusions from the Classroom Observations

Finding 1. The teacher was the primary person asking questions while the students were the consumers of mathematics. In four of the six classroom observations, the teacher was telling and showing students how to do math. The students were responding to the math presented by the teacher, as opposed to offering their own mathematical ideas. Teaching for mathematical proficiency requires appropriate discourse in the classroom (McGatha & Bay-Williams, 2013), and students cannot simply be consumers of mathematical knowledge. I speculate the teachers were asking the questions because these four teachers possibly lacked confidence to answer unexpected questions from their students. Therefore, if they continued asking questions to the students, the students would not have time to ask questions to the teacher. Teachers should allow and encourage students to ask and answer questions. According to the National Research Council (2001), teachers should model classroom discourse, and study discourse via case studies of other teachers to improve the quality of their own classroom discourse. Unfortunately, when the teacher takes charge, and does not allow for discourse, little mathematics is illuminated for the students (Webb et al., 2017). Teachers play an important role in supporting effective student collaboration (Webb et al., 2017). Instruction, including questioning during lessons, is more effective in producing achievement gains than instruction carried out without questioning students (Cotton, 1988). In short, the teacher's role in discussions is critical (Smith & Stein, 2011).

Finding 2. Teachers have a fixed mindset about teaching mathematics and need to shift from univocal to dialogic discourse. Carter (2008) said it best, "If you are not struggling, you are not learning" (p. 136). Struggle is a natural part of the learning process. Research from the NCTM (2000b) suggests that teachers with a fixed mindset are more likely to give up when they encounter struggle. The classroom lessons I observed should have implemented more dialogic discourse to improve a growth mindset in the teachers. Teachers using verbal and non-verbal communication techniques to promote perseverance encourages a growth mindset (National Council of Teachers of Mathematics, 2000b). The purpose of the dialogic discourse is to generate new meaning (Otten et al., 2015), and all of the teachers I observed were attempting to generate new meaning during the six lessons I observed. Without experiences with dialogic interaction in classroom contexts, students and teachers are likely to have difficulty overcoming the frequency of univocal discourse. Teachers need the practice to work out the logic of their ideas and put together a persuasive argument for the topic at hand.

Teacher practice needs to continue shifting from univocal questioning to dialogic discourse (Hufferd-Ackles et al., 2004; McGatha & Bay-Williams, 2013). During my classroom observation, the teacher was the primary person who asked questions throughout all six lessons. What is needed is both teachers and students asking and answering questions in the math classroom. When teachers have shifted from teacher to co-learner, teachers then expect students to ask one another questions about their work (Hufferd-Ackles et al., 2004). Teachers can use questions to gather information about what students understand. Likewise, effective questioning can help move students forward (Chval, Lannin, Jones, & Dougherty, 2013). Teachers should be reminded that getting students to talk about mathematics is one of the best ways to engage in formative assessment (Anderson et al., 2011).

Finding 3. Teachers must anticipate student responses. When considering the classroom observation finding that teachers must anticipate students' responses, I would recommend teachers participate more actively in anticipating students' ideas. Perhaps teachers have not adequately planned due to a lack of time or having to teach multiple subject areas. In my classroom observations, teachers did not work the problems in many ways, before teaching, as research suggests is a best practice for anticipating what may happen during a lesson (Smith & Stein, 2011). Since teachers must make decisions quickly within a lesson, it is important teachers anticipate the responses students may or may not have when asking questions (Smith & Stein, 2011). I recommend teachers plan and prepare with their teammates, to collaboratively come up with a list of potential misconceptions and questions students may ask for a particular lesson as suggested by Smith and Stein (2011).

Limitations of the Study

Limitations are features of the study, which may negatively affect the results of the survey or the ability to generalize the results (Roberts, 2010). This study has three main limitations, self-reporting, a lack of generalizability, and the prescribed curriculum.

Self-Reported Survey Data

Since the survey results were self-reported, they are subjective in nature. Teachers may respond to surveys in a manner that is less representative of their teaching than their real teaching practices reveal. Teachers may have taken a low priority of completing this survey because of other urgent daily tasks teachers must accomplish.

Respondents may not feel comfortable answering questions in an honest manner. Since I work for the district, respondents may answer survey items in a manner in which they think I would want them to, as opposed to a truthful response. For all of these reasons related to self-reporting, study results may have been impacted.

Generalizability of Study

These findings are suggestive, but not generalizable to all elementary and middle grades teachers. Since I only sampled one of the four executive director's schools in the school district, the results are only generalizable to this one school district and other similar districts. If I were able to survey the teachers from all other school districts, the results would be more representative of the entire population of math teachers.

County-Mandated Curriculum

Unfortunately, the school district where I conducted this research was conducted utilized prescribed content, which limits the teachers' ability to choose appropriate tasks to encourage discourse, specifically dialogic discourse. Researchers suggested that it is critical for teachers to choose the most appropriate kinds of tasks which encourage discourse (Stein et al., 1996). Interesting problems that have multiple entries and exit points mathematically can often be catalysts for rich conversations (Larsen & Bartlo, 2009) and maximize the instructional potential (SanGiovanni, 2016).

Recommendations for Future Research

An additional qualitative follow-up interview component would allow teachers to explain and justify their perceptions about which standards and tasks encourage more dialogic discourse, and which standards and tasks encourage more univocal discourse. The task a teacher chooses significantly influences students' thinking (Kimani et al., 2016; SanGiovanni, 2016). Tasks which encourage students articulate and justify their mathematical ideas are best (Carpenter, Franke, & Levi, 2003). Equally as important is students' ability to explain and provide a rationale for their answers (Carpenter, Franke, & Levi, 2003). Current research includes a large body of case studies among teachers and their uses of discourse (Bennett, 2010; Dogruer et al., 2015).

Because my study only focused on a single moment, I did not track changes in teachers' perceptions. Future research could include a longitudinal study that shows how teachers' perceptions of their classroom discourse change over time or over the course of a year given specific professional development focusing on dialogic discourse. This type of study would allow researchers to expose a sequence of events for developing successful discourse. Additionally, a longitudinal study of the same cohort of teachers would allow for a higher level of validity than this current study.

A study, which focused on the quality of discourse, would be beneficial. Instead of teachers' perceptions of discourse, researchers could study the level of quality of their current discourse practices. It would be beneficial to interview teachers in a small group forum and allow them to discuss their perceptions of discourse. Teachers may perceive that dialogic discourse occurs more often or more appropriately while they are working with a small group of students. They may feel dialogic discourse is not attainable during whole class mathematics time. It would be beneficial to further investigate teacher perceptions of dialogic discourse in a forum to see what classroom setting works best for them.

It may be beneficial to conduct a study, that compares students' perceptions to the teachers' perceptions of different discourse types to determine any discrepancy existing between student and teacher perceptions of their current classroom practices. Since teachers would be self-reporting their data for a survey of this nature, they are oftentimes not reporting what is truly happening in their classrooms. Students would be more honest in their responses about discourse occurring or not occurring in class.

Student gender and teacher gender could also be explored. Some research shows girls respond with more dialogic type discourse than boys (Leyva, 2017). Teachers' perceptions of their discourse types showing discourse with different genders would be an interesting component to add to such a study. “Interactions between teacher and student need to be appropriate to the student and the content, regardless of the student's social class, ethnicity, language, or gender” (Kilpatrick & Swafford, 2013, p. 344). Teachers' perceptions of discourse and gender have yet to be studied.

Conclusion

The NCTM's (2000) *Principles and Standards for School Mathematics* claim it is beneficial to have students engaged in rich discussions, not merely explaining steps they took to solve a problem (NCTM, 2000a; NCTM, 2000b; NCTM, 2014). Teaching with productive struggle leads to long-term benefits, with students more able to apply their learning to new problem situations (NCTM, 2014). The implications from this study offer insight into teachers' perspective of their discourse practices. The findings do imply that dialogic discourse could be improved. Dialogic discourse will continue to be the least used type of discourse without any intervention. According to the NCTM (2014), learners need to have experiences that can enable them to construct knowledge socially through discourse and interaction related to significant problems.

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APPENDIX A

Measuring Teachers' Perceptions of Discourse Instrument

Adapted from Truxaw, Gorgievski, & DeFranco (2008) with permission (Appendix B)

Demographic Information: A. Grade level(s) of current teaching assignment:
K 1 2 3 4 5 6 7 8 other (specify) ____________________________

B. Do you currently teach mathematics?
1 - Yes
2 - No

C. Years of teaching experience that will be completed by the end of this school year:
1 – 0 to 5 years
2 – 6 to 10 years
3 – 11 to 15 years
4 – More than 15 years

~~D. Years of teaching experience (by the end of this school year) that you have taught mathematics:~~
~~1 – 1 to 5 years~~
~~2 – 6 to 10 years~~
~~3 – 11 to 15 years~~
~~4 – More than 15 years~~

D. The highest level of education completed:
1 – Associate's degree
2 - Bachelor's degree (T-4)
3 – Master's degree (T-5)
4 – Sixth year (T-6) or above
~~5 – Doctorate (T-7)~~

~~E. Gender:~~
~~1 – Female~~
~~2 – Male~~

~~G. Current National Council of Teachers of Mathematics (NCTM) member:~~
~~1 – Yes~~
~~2 – No~~

Survey Directions – *for this study, discourse will be defined as a verbal expression within mathematics classes. Please chose one response for each of the following (1 to 18) statements to indicate the frequency the practice occurs in your mathematics class(es).*

1 — Seldom/Never
2 — Occasionally
3 — To A Considerable Degree
4 — Very Often
5 — Almost Always

1. In my mathematics class(es) I encourage discussion.
2. In my mathematics class(es) I ask students to justify their mathematical ideas.
3. In my mathematics class(es) I ask students to repeat the steps of mathematical procedures verbally.
4. In my mathematics class (es) students, lead mathematical discussions.
5. In my mathematics class(es) discussions, help students to generate their own meaning of mathematical topics.
6. During discussions in my mathematics class(es), I verbally assess students' responses.
7. Verbal communication is an important part of learning in my mathematics class(es).
8. In my mathematics class(es) communication is used to convey exact ideas to students.
9. In my mathematics class(es) learning involves the negotiation of mathematical meanings.
10. In my mathematics class(es) I evaluate the correctness of students' responses.
11. In my mathematics class(es) I ask students to explain their mathematical ideas.
12. In my mathematics class(es) discussions help students analyze problem-solving strategies.
13. In my mathematics class(es) discussions encourage students to replicate procedures precisely.
14. During discussions in my math class(es) I follow up student responses by probing for understanding.
15. In my math class(es) I ask students for alternative strategies.
16. Discussions in my mathematics class(es) are geared toward informing students about mathematical procedures.
17. In my mathematics class(es) all students participate in discussions.
18. In my math class(es) I ask students to elaborate verbally on their mathematical ideas.

Questions regarding the purpose or procedures of the research should be directed to Beth Tuck at 912-220-6940 or batuck@valdosta.edu. This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-259-5045 or irb@valdosta.edu.

APPENDIX B

Permission to Use and Modify Instrument from Truxaw et al. (2008)

Re: K-8 Mathematics Teachers[1] Perceptions about Discourse in Their Mathematics Classes

Truxaw, Mary

Wed 7/6/2016 1:33 PM

To: Beth A Tuck <batuck@valdosta.edu>;

Dear Beth,

You have my permission to use and modify the survey mentioned in your email below.
If you need a more formal permission, please let me know.

I wish you the best in your research endeavors.

Mary

Mary P. Truxaw, Ph.D.
Associate Professor, Mathematics Education
University of Connecticut
Neag School of Education
249 Glenbrook Road, Unit 3033
Storrs, CT 06269

Office: Gentry 413A
Phone: 860-486-2880
Fax: 860-486-0280
Email: mary.truxaw@uconn.edu

From: Beth A Tuck <batuck@valdosta.edu>
Date: Wednesday, July 6, 2016 at 1:21 PM
To: Mary Truxaw <mary.truxaw@uconn.edu>
Cc: "a123snoopy@aol.com" <a123snoopy@aol.com>
Subject: K-8 Mathematics Teachers' Perceptions about Discourse in Their Mathematics Classes

Wednesday, July 6, 2016

Good morning Dr. Truxaw,

I am a doctoral student from Valdosta State University writing my dissertation prospectus titled "Descriptive Survey Examination of Teachers' Perceptions of Discourse Usage in Kindergarten through Eighth Grades Mathematics". Currently, I am a math coach in Savannah, GA and have a great interest in the lack of discourse I encounter daily.

I would like your permission to use and slightly modify your instrument titled "K-8 Mathematics Teachers' Perceptions about Discourse in Their Mathematics Classes" in my study. If approved by the university, I will gladly send a copy of my completed research study to your attention upon completion of the study.

I look forward to hearing from you and perhaps speaking with you further about future research interests you have for this particular instrument.

Respectfully,

Beth Tuck

Doctoral Student at Valdosta State University
E-mail: a123snoopy@aol.com
E-mail: batuck@valdosta.edu
Cell: 912-220-6940

APPENDIX C

Qualtrics Survey Sample

Survey: Teachers' Perceptions of Discourse Usage in Elementary and Middle Grades Mathematics

Teachers, thank you for taking the time to answer these survey questions truthfully and anonymously. This should take approximately 3 minutes of your time.

Beth

Questions regarding the purpose or procedures of the research should be directed to Beth Tuck at 912-220-6940 or batuck@valdosta.edu. This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-259-5045 or irb@valdosta.edu.

A Grade level of current teaching assignment:
Kindergarten to 2nd grade (1)
3rd grade to 5th grade (2)
6th grade to 8th grade (3)

B Do you currently teach mathematics?
Yes (1)
No (2)

C Years of teaching experience that will be completed by the end of this school year:
0 to 5 years (1)
6 to 10 years (2)
11 to 15 years (3)
More than 15 years (4)

D-Highest level of education completed:
Associate's degree (1)
Bachelor's degree (T-4) (2)
Master's degree (T-5) (3)
Sixth year (T-6) or above (4)

Survey Directions – for this study, discourse will be defined as a verbal expression within mathematics classes. Please chose one response for each of the following (1 to 18) statements to indicate the frequency the practice occurs in your mathematics class(es).

1 - Seldom/Never
2 - Occasionally
3 - To A Considerable Degree
4 - Very Often
5 - Almost Always

In my mathematics class(es) . . .
. . . I encourage discussion. (G)
. . . I ask students to justify their mathematical ideas. (D)
. . . I ask students to repeat the steps of mathematical procedures verbally. (U)
. . . students, lead mathematical discussions. (D)
. . . discussions, help students to generate their own meaning of mathematical topics. (D)
. . . I verbally assess students' responses. (U)
. . . Verbal communication is an important part of learning (G)
. . . communication is used to convey exact ideas to students. (U)
. . . learning involves the negotiation of mathematical meanings. (D)
. . . I evaluate the correctness of students' responses. (U)
. . . I ask students to explain their mathematical ideas. (D)
. . . discussions help students analyze problem-solving strategies. (D)
. . . discussions encourage students to replicate procedures precisely. (U)
. . . I follow up student responses by probing for understanding. (D)
. . . I ask students for alternative strategies. (D)
. . . Discussions are geared toward informing students about mathematical procedures. (U)
. . . all students participate in discussions. (G)
. . . I ask students to elaborate verbally on their mathematical ideas. (D)

Questions regarding the purpose or procedures of the research should be directed to Beth Tuck at 912-220-6940 or batuck@valdosta.edu. This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-259-5045 or irb@valdosta.edu.

APPENDIX D

Administrative Cover Letter for Emailed Survey with Survey Consent Statement

Tuesday, August 15, 2017

Administrators,

Thank you for taking a moment to forward this email to your certified staff. I appreciate you for doing so. The survey link will be active from August 16, 2017 to September 5, 2017.

Beth

Tuesday, August 15, 2017

Teachers,

You are being asked to participate in a survey research project entitled "Teachers' Perceptions of Discourse Usage in Elementary and Middle Grades Mathematics", which is being conducted by Beth A. Tuck, a student at Valdosta State University. This survey is anonymous. No one, including the researcher, will be able to associate your responses with your identity. Your participation is voluntary. You may choose not to take the survey, to stop responding at any time, or to skip any questions that you do not want to answer. You must be at least 18 years of age to participate in this study. Your completion of the survey serves as your voluntary agreement to participate in this research project and your certification that you are 18 or older. The survey link will be active from August 16, 2017 to September 5, 2017.

Questions regarding the purpose or procedures of the research should be directed to Beth A. Tuck at 912-220-6940 or beth.tuck@sccpss.com. This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-259-5045 or irb@valdosta.edu.

https://valdosta.co1.qualtrics.com/jfe/form/SV_0CcRL5aJAGYI6EJ

APPENDIX E

Valdosta State University IRB Approval

VALDOSTA STATE UNIVERSITY

Institutional Review Board (IRB)
For the Protection of Human Research Participants
PROTOCOL EXEMPTION REPORT

PROTOCOL NUMBER:	**03490-2017**	**INVESTIGATOR:**	**Ms. Beth Tuck**
		SUPERVISING FACULTY:	**Dr. Nicole Gibson**
PROJECT TITLE:	***Teachers' Perceptions of Discourse Usage in Elementary and Middle Grades Mathematics.***		

INSTITUTIONAL REVIEW BOARD DETERMINATION:

This research protocol is **Exempt** from Institutional Review Board (IRB) oversight under Exemption **Category 2**. You may begin your study immediately. If the nature of the research project changes such that exemption criteria may no longer apply, please consult with the IRB Administrator (irb@valdosta.edu) before continuing your research.

ADDITIONAL COMMENTS:

- *Upon completion of your research study, compiled data must be maintained (locked file cabinet, password protected computer, etc.) for a minimum of 3 years.*

☒ ***If this box is checked, please submit any documents you revise to the IRB Administrator at irb@valdosta.edu to ensure an updated record of your exemption.***

Elizabeth W. Olphie *6/30/2017*

Elizabeth W. Olphie, IRB Administrator Date

Thank you for submitting an IRB application.
Please direct questions to irb@valdosta.edu or 229-259-5045.

Revised: 06.02.16

APPENDIX F

SCCPSS IRB Approval

SCCPSS

June 22, 2017

To Whom It May Concern:

Ms. Beth Tuck has requested and been granted permission to conduct research within the Savannah-Chatham County Public School System on the following topic:
Teacher's Perceptions of Discourse Usage in Elementary and Middle Grades Mathematics

This permission has been granted by the office appointed by the Superintendent of schools to review all requests for research to be conducted within the Savannah-Chatham County Public School System. Ms. Tuck has fulfilled the application requirements and provided the documentation necessary to ensure that we understand the scope of research and the methods used to collect and present findings.

All prospective researchers must note that district approval does not guarantee participation of any site, program area, or individual. The school principal or program supervisor will make the final determination on whether research activity may proceed at the site or program level. Individual participants may decline to participate or discontinue participation at any time.

Should you have any questions regarding Ms. Beth Tuck research approval status, please feel free to contact me at (912) 395-5735.

Thank you,

Kristy Collins Rylander
Savannah-Chatham County Public School System
Office of Accountability, Assessment, & Reporting
(912) 395-5735 kristy.collins-rylander@sccpss.com

Office of Accountability, Assessment, & Reporting

Appendix F

Teacher Consent for Classroom Visit

Teacher,

You are being asked to participate in a classroom visit for research study entitled "Teachers' Perceptions of Discourse Usage in Elementary and Middle Grades Mathematics," which is being conducted by Beth A. Tuck, a student at Valdosta State University. The purpose of this study is to assess group differences in teachers' perceptions of univocal, dialogic, and general discourse. In addition, differences due to the level of experience and education will be explored. Your participation is voluntary. You may choose not to participate. You must be at least 18 years of age to participate in this study. Your signature serves as your voluntary agreement to participate in this research project and your certification that you are 18 or older.

Questions regarding the purpose or procedures of the research should be directed to Beth Tuck at batuck@valdosta.edu. This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-259-5045 or irb@valdosta.edu.

Teacher Signature: ____

APPENDIX G

Crosstabulations

Grade Level * Degree Crosstabulation					
			Degree		
			Associate's / Bachelor's	Master's / Higher	Total
Grade Level	Elementary	Count	70	123	193
		%	36.3%	63.7%	100%
	Middle	Count	4	16	20
		%	20%	80%	100%
Total		Count	74	139	213
		%	34.7%	65.3%	100%

Grade Level * Experience Crosstabulation					
			Experience		Total
			0-10 Years	11+ Years	
Grade Level	Elementary	Count	79	114	193
		%	40.9%	59.1%	100%
	Middle	Count	8	12	20
		%	40%	60%	100%
Total		Count	87	126	213
		%	40.8%	59.2%	100%

Experience * Degree Crosstabulation					
			Degree		Total
			Associate's / Bachelor's	Master's / Higher	
Experience	0-10 Years	Count	42	45	87
		%	48.3%	51.7%	100%
	11+ Years	Count	32	94	126
		%	25.4%	74.6%	100%
Total		Count	74	139	213
		%	34.7%	65.3%	100%