CHANGES IN TEACHER BELIEFS AND DISCOURSE ECOLOGY IN MIDDLE-SCHOOL MATHEMATICS CLASSROOMS

A Record of Study

by

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ABSTRACT

This Record of Study summarizes my journey in the program and my investigation of the problem of improving mathematics instruction. The exploration of the problem space spanned three years before culminating in the problem statement. Using a positive deviance approach and understanding the values of stakeholders narrowed the scope of the problem of practice. Successful teachers, positive deviants, demonstrated the ability to implement strategies learned in professional development in their classrooms. Struggling teachers in similar sessions made only token attempts, if they even remembered the strategies shared. The gap between what is shared with teachers in traditional professional development workshops and the implementation of change in the mathematics classroom became the focus of research. A review of mathematics education literature, as well as that dedicated to improving professional learning, inspired a coaching follow-up intervention as a potential solution to the problem. Student discourse was a focus of professional development and is supported by literature as a critical strategy in facilitating student construction of mathematics concepts. The coaching intervention was provided to classroom teachers as a follow-up to traditional and online professional development on student discourse. In order to understand the possible impact and potential effectiveness of intervention, the following research questions were investigated:

1. Were there changes in teachers' beliefs post-coaching intervention—specifically, how did teacher beliefs change regarding student discourse and their role as a teacher in facilitating student discourse?
2. Were there changes in teachers' ability to facilitate student discourse in the mathematics classroom?

The coaching intervention consisted of four classroom observations, feedback for each observation to the classroom teacher, discussions within Professional Learning Community meetings, and face-to-face and virtual communication via e-mail. All four teachers demonstrated a change in beliefs specifically relating to the importance of student discourse. They also demonstrated an increased capacity for facilitating student discourse on a higher cognitive level as measured on some, if not all, discourse ecology factors.

DEDICATION

This work is dedicated to my late mother, Charliene Hearn. She always inspired her children to seek lofty goals, especially in education. It was her dream for us to have the highest degree possible. Soon all of her daughters will have the terminal degree in their fields—PhD, EdD, or JD.

"The goal of education is the advancement of knowledge and the dissemination of truth."

–John F. Kennedy

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Finally, I would like to acknowledge my daughter, Violet Coker, who inspires me to be a role model and keeps me grounded. I wish her the very best, always.

NOMENCLATURE

CMP	Connect Mathematics Project
CoP	Community of Practice
DSTCP	Dynamic Student Teacher Communication Pathway
ELL	English language learner
ESC	Education Service Center
IRB	Institutional Review Board
MKT	Mathematical Knowledge for Teaching
NCTM	National Council of Teachers of Mathematics
NSF	National Science Foundation
PAEMST	Presidential Award for Excellence in Mathematics and Science Teaching
PBL	Project-Based Learning
PEMDAS	Parentheses-exponents-multiply-divide-add-subtract
PFL	Personal financial literacy
PLC	Professional Learning Community
PVCD	Professional vision of classroom discourse
RMD	Robust Mathematical Discussion
ROS	Record of Study
STAAR	State of Texas Assessments of Academic Readiness
TBQ	Teacher Belief Questionnaire
TPQ	Teacher Practice Questionnaire

TABLE OF CONTENTS

Page

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

Page

Page

CHAPTER I

INTRODUCTION

Framing the Problem

In order to solve complex problems like those found in education, leaders must take the time to fully explore all aspects of the context. Cuban (2001) recommended "taking the time to reframe a situation" (p. 24) in order to find alternative ways to solve the problem or negotiate a compromise that may not have been obvious before. It is through reframing this problem of poor student performance on standardized mathematics exams that I discovered the proposed solution.

Context

The Region 10 Education Service Center (ESC) supports 53,000 educators in 80 public school districts, 31 charter schools, and numerous private schools in eight counties (and a portion of a ninth county) in north Texas. Established in 1967 by the Texas State Legislature, Region 10 ESC's mission is to provide a "wide array of high quality, innovative products and services, efficiently and economically" (Region 10 Education Service Center, 2006, para. 2). Instructional Services within Region 10 ESC provides support for instruction, curriculum, and assessment in the four content areas, as well as many other specialized areas such as Bilingual, English as a Second Language, and Migrant. The Effective Practices Group within Instructional Services focuses on supporting teachers by providing professional development for mathematics, science, social studies, and cross-content instructional practices. All public school districts within the Region 10 ESC service area, as well as several charter and private schools, are part of a Title II Professional Development Cooperative. The majority of the Title II Cooperative professional development provided by Region 10 is in the form of face-to-face workshops in six-hour, three-hour, or after-school timeframes. In addition, Region 10 shares critical information via online professional development courses, synchronous Webinars, and video recordings. It is through these services that Region 10 hopes to support superior student performance by improving classroom instruction.

The National Research Council described mathematical proficiency as having five components: conceptual understanding, computational fluency, ability to apply mathematics to solve problems, ability to reason logically, and ability to understand the utility of mathematics (Kilpatrick, 2002). On the state's standardized assessments, however, performance data for students in the region indicate that approximately 20% of middle-school students within Region 10 have not been successful in mathematics in the middle grades. In addition, the implementation of new standards for mathematics in 2014–2015 for kindergarten through eighth grade has created artificial gaps in student knowledge, putting additional students at risk and significantly increasing the quantity of mathematics content that students must master. Mathematics consultants at Region 10 ESC provide professional development to support these teachers as they work to increase usage of research-based instruction in the mathematics classroom. Unfortunately, as teachers have struggled with the implementation of the new mathematics standards, many appear to be retreating to teacher-centered, lecture-style instructional strategies that may not provide the support required for students to construct mathematical understanding through discourse.

Initial Understanding

When examining the gap between the expectations for student performance and their actual performance, the cause appeared to be the lack of mathematics teachers' content and pedagogical knowledge. This initial understanding was based on information learned about how important content knowledge is to effective mathematics instruction (Joyce, Weil, & Calhoun, 2009), as well as conversations with other mathematics consultants at Region 10 ESC. Some personal reflections on the reasons listed include "teachers don't understand content—difficult to teach it correctly without understanding," "teachers don't 'see' math in the world...[so they] can't help students," and "math pedagogy [is] weak." During the same period, district leaders began to express concern about teacher-centered instruction and students not having deep mathematical discussions. These concerns were substantiated by various classroom observations requested during the 2013–2014 school year. While some teachers facilitated student discourse, others seemed only able to ask simple, closed questions requiring little student reflection or rigorous thought necessary to develop mathematical understandings.

Relevant History of the Problem

In the 2011–2012 school year, the state of Texas began using a new standardized assessment, State of Texas Assessments of Academic Readiness (STAAR). As compared to the previous test design, these assessments include more rigorous items to "[assess] skills at a greater depth and level of cognitive complexity" (Texas Education Agency, 2010, para. 4). Table 1 summarizes the performance of middle-school students within Region 10 on the mathematics STAAR in its first three years. There are three important conclusions supported by Table 1:

- Each year, between 20% and 30% of middle-school students were not academically ready to progress in mathematics
- As was the original plan set by the Texas Commissioner of Education, significant improvements were not occurring in student performance.
- Only a small percentage of students were successful enough on the assessments to meet the "Advanced – Level III" performance criterion.

Table 1

*Region 10 Mathematics STAAR Data: Students Who Met Level II Phase I Passing Standard and Final Level III Advanced Standard**

	2012		2013		2014	
Grade Level	Passing	Advanced	Passing	Advanced	Passing	Advanced
Sixth grade	80%	23%	61%	6%	80%	21%
Seventh grade	73%	13%	74%	12%	70%	14%
Eighth grade	79%	10%	77%	5%	80%	9%

*From 2012, 2013, and 2014 campus summary reports

Each year, the mathematics consultants at Region 10 ESC analyze student assessment data, data from districts, and observations in the field. Additionally, they review research on effective teaching practices to develop a plan to provide the support teachers and leaders need to improve instruction and student performance. After analysis of the 2012 and 2013 data, Region 10 ESC mathematics consultants determined that necessary levels of student discourse were lacking in many mathematics classrooms in the region. Hufferd-Ackles, Fuson, and Sherin (2004) described a Math Talk Community as one in which students "assist one another's learning of mathematics by engaging in meaningful mathematical discourse" (p. 81). As a result, Region 10 ESC created three workshops focused on strategies to increase student discourse in the classroom—one for each grade band. The purpose of the workshops was to increase student questioning, explaining, justifying, and reasoning about mathematical ideas, either with each other or with the teacher. In addition, many other created workshops incorporated discourse strategies such as the study of mathematical process skills encompassing representation, generalization, and justification aspects of a Robust Mathematical Discussion (RMD) presented by Mendez, Sherin, and Louis (2007). By using this approach, we assumed that teachers did not have the pedagogical knowledge necessary to engage students in mathematical discourse and sought to provide teachers with that knowledge.

In spite of this emphasis, results of classroom observations in the fall of 2014, as well as discussions with district and campus leaders, seemed to indicate that students were rarely talking about mathematics. In 25 classroom observations at one campus, students were generally quiet, and when they spoke about mathematics in the classroom it was in response to a closed question requiring minimal elaboration or justification. In face-to-face workshops and facilitated planning sessions, teachers expressed their concerns about the gaps created by the new math standards and their students' lack of preparedness for the new content. As a result, several teachers described how they felt the need to spend time reteaching or reviewing absent prerequisite skills, which meant that they did not have time to let students discuss mathematics. At the same time, school district leaders continued to express concerns about teacher-centered instruction and the lack of student discourse.

Using Positive Deviance Model

In order to further clarify the underlying reasons for the problem, I used the concept of positive deviance from Pascale, Sternin, and Sternin (2010). By comparing how successful teachers make positive changes in their classroom instruction following professional development with the response of struggling teachers, I was able to isolate critical elements needed for change. I began by talking with teachers who were successful. One successful teacher identified had been selected by her state as a finalist for the Presidential Award for Excellence in Mathematics and Science Teaching (PAEMST). (She is currently awaiting word about the state's winner.) Another successful teacher identified was one of the Region 10 ESC consultants. She was successful enough implementing numeracy strategies in her classroom to be asked to present professional development for Pamela Harris, lecturer at the University of Texas and author of *Building Powerful Numeracy for Middle and High School Students* (2011).

In sharing their journeys, both these successful teachers recalled being interested in an idea or strategy presented at a conference or workshop, seeking additional information as they attempted to incorporate the new strategy, and persevering until they were successful. However, during observations and conversations with struggling teachers, I heard from them about the experiences of learning about interesting strategies in professional development workshops but not implementing them—either dismissing the strategies because they did not believe their students were capable or expressing their need for more information or assistance but not seeking it out. Instructional coaches, campus and district leaders, and Region 10 ESC consultants reported that although they provided struggling teachers with professional development (personally or through another presenter), classroom observation data indicated that either teachers made a token attempt at implementation or made no attempt at all to change classroom instruction. Leaders concluded that they failed to facilitate essential change in classroom instruction.

In reviewing regional data and classroom observations, Region 10 ESC mathematics consultants agreed that teachers need to encourage an increase in student discourse to facilitate student construction of mathematical concepts. After developing three separate workshops with an emphasis on student discourse, productive student discourse was rarely observed in classrooms. While successful teachers seemed to be able to seek out the support and additional information necessary to bridge this gap following workshops, many other teachers did not.

Stakeholder Groups and Values

All stakeholders shared a common goal—student success in mathematics. However, the professional development workshop model did not appear to meet the needs of struggling teachers. While teachers and administrators expressed frustration over the situation, they did not appear to blame Region 10 ESC. This situation represented a problem rather than a dilemma because of the shared goal of student success and because stakeholders did not blame each other. This problem seemed to require that Region 10 ESC consider small but innovative changes to the current workshop model to provide the additional support necessary for struggling teachers to make the desired changes in their classrooms.

Explorations of the problem space early in the fall 2014 internship focused on the political values that seemed to dominate districts and campuses. The 2014–2015 school year was the first year of implementation of the newly adopted mathematics standards for kindergarten through eighth grade in the state. The new standards represented a significant change in mathematics content at all grade levels. Many teachers shared concerns about their unfamiliarity with the new mathematics content they were required to share with students. They also shared concerns about their students' lack of preparedness for the new-grade-level content due to the artificial gaps created by the movement of several standards down one or more grade levels. (This meant that students were not taught the prerequisite skills for the grade-level content—For example, integer operations concepts were taught to seventh-grade students in 2013, but in 2014 moved with the new standards to sixth grade. Students in sixth grade in 2013 did not learn integer operations, but were expected to know them for the content they needed to learn in 2014 in seventh grade.) In addition, teachers also experienced pressure to increase student test scores on the more rigorous STAAR exam in the spring. Teachers at several campuses reported having to attend weekly “data meetings” with supervisors. These pressures and lack of confidence in the mathematics content initially appeared to create a political focus for teachers. Teachers shared that they wanted to make changes in instruction, but felt that students had too many gaps to be filled, which conflicted with pressures to present the new-grade-level material at even more rigorous levels.

The struggle in the districts articulated by mathematics teachers and leaders mirrored the conflict between their social value of wanting to help students be successful and their political/survival values related to student performance expectations on district benchmarks and the state’s standardized assessment. In addition to student STAAR performance being used on teacher appraisal and compensation systems, several teachers mentioned concerns about getting their contract renewed to teach the next year. Similar conflicts were seen at Region 10 ESC. Mathematics consultants wanted to support teachers in helping students, but this social value conflicted with the limited resources of the ESC. While consultants wanted to help teachers, only one consultant was allocated to help over 1,000 middle-school mathematics teachers throughout the region who taught almost 150,000 students enrolled in sixth-, seventh-, or eighth-grade mathematics.

My Journey in the Problem Space

Creswell (2013) described the importance of positioning oneself within any research reported. This section describes personal and professional roles within the context of the research. In order to develop a solution that would have some chance of success, I sought to understand the values of the stakeholders. Considering these values was important in the reframing process, as described below.

My Background

At the time of the intervention, I had 11 years of experience as a classroom teacher and three years as a consultant at Region 10 ESC. I have several funding sources at Region 10, including the Schools in Improvement Grant, Texas Regional Collaborative Grant, Title II Cooperative local funds, English Language Proficiency Standards state funds, and Least Restrictive Environment federal funds. I have been responsible for supporting middle-school mathematics teachers in the region—with some opportunities to help other-grade-level mathematics teachers and science teachers. This support generally took the form of writing and presenting professional development workshops, as well as providing instructional coaching. My values in this role include respect for others (staff members, students, and parents), helping (all succeed), obligation to clients (staff members, students, and parents), obligation to organization (Region 10 ESC), and effectiveness (how to make the changes needed to improve instruction). Due to the many hours I have spent on campuses with math coaches and teachers, I also feel a sense of loyalty to them.

My Field-Based Supervisor

Dana Grieb, previously Coordinator of Effective Practices, was promoted during the course of my research to Assistant Director of Instructional Services. Ms. Grieb has extensive experience in leading and supporting instructional improvement at the campus and district level. She was uniquely positioned to help frame the problem and assess potential solutions. As my former supervisor, Ms. Grieb not only was responsible for assigning me to coach at the various campuses, but she also reviewed and approved all professional development workshops created. She further served as a sounding board for clarifying my understanding of the problem, district politics, and the potential benefits and pitfalls of my proposed solution. She provided inspiration and clarity as we discussed the problems facing educators in the region.

The Evolution of My Current Understanding

Prior to the fall 2014 internship, I assumed that issues were based on psychological or organizational issues. It was simple to conclude that teachers did not have the content and pedagogical knowledge to conduct productive student discourse in their classrooms in order to build students' conceptual understanding of mathematics. However, once I listened to teachers and leaders at the campuses, I was made acutely aware of the conflicting values of wanting to help students and wanting to maintain employment. This conflict was echoed at the administrator level as well. Administrators wanted to help teachers improve, but were also driven by the pressure to produce improved student test scores within the new mathematics standards. Finally, I focused on both the specific concern of increasing student discourse and the more general idea that professional development workshops appeared to be ineffective in facilitating the desired changes in mathematics classrooms. This reflection resulted in a cultural perspective on the problem. The heart of the problem was changing teacher behaviors to incorporate changes supporting increased student discourse. Teachers needed support as they attempted to make changes to instructional practices, especially in a politically charged year of changing standards. My final understanding developed when I returned to conversations with successful teachers, my field supervisor, and fall 2014 internship instructor. The following problem statement represents the reframing of the problem in light of the cultural perspective and identifies actions Region 10 ESC can implement to support the kinds of action described by research as being effective in facilitating students' learning of mathematics.

Problem Statement

Audience

One of the goals of Region 10 ESC is to support school initiatives for improving excellence and equity in student achievement and enhance the efficiency and effectiveness of educational programs throughout the region. Instructional Services within Region 10 ESC works directly to improve student achievement with teachers and administrators. This proposal was directed to James Matthew, Director of Instructional Services. He and his new coordinator for the Effective Practices Group, Sally White, will be the individuals at Region 10 ESC who review the results of my research and decide if the data generated meet the ESC goals for an efficient and effective approach for increasing excellence and equity in student achievement.

Ideal Scenario

Instructional Services at Region 10 ESC provides professional development and support for teachers to improve student learning. Consultants work tirelessly to share information with teachers throughout the region on effective instructional practices in all content areas. One such effective practice is discourse ecology in the mathematics classroom. In 2013–2014, Region 10 ESC mathematics consultants created three new professional development workshops focused on providing strategies teachers could employ to encourage students to talk about concepts with each other in order to help them construct their mathematical knowledge (discourse ecology). Mathematical communication is a central component of both the National Council of Teachers of Mathematics (NCTM) and Texas's process standards because of its significant role in helping all students develop mathematical understandings, especially English language learners (ELLs). In an ideal situation, teachers would be able to take the information shared about student discourse in a traditional workshop, examine their own instructional practices, adapt the strategies presented, and determine which strategies to implement in their particular classrooms. Then, if desired, teachers would have access to "sustained and in-depth" follow-up support, recommended by Loucks-Horsley, Stiles, Mundry, Love, and Hewson (2010, p. 53), to facilitate successful implementation of instructional practices to increase student discourse. However, that follow-up support is currently not a part of the Region 10 ESC model for professional development. As a result, the professional development currently being provided may not be as effective as desired.

The Real Situation

In spite of providing many different sessions on student discourse during the 2013–2014 school year, classroom observations revealed that during enacted lessons teachers were still the central focus for providing mathematics information. Students spent little time in conversations justifying and explaining mathematics with each other in small or large groups or with the teacher. Informal conversations with these teachers revealed concerns about letting students talk in class. One teacher stated that she was worried she would have to “un-teach” something another student might share. Other teachers reported in post-workshop surveys and conversations that they agreed that student discourse showed promise, but they needed more specific strategies and additional support to implement them effectively in their classrooms. In addition, as teachers implemented the new mathematics standards, they shared that they felt intense pressure to teach a large amount of information in a very limited amount of time. Classroom and planning session observations revealed that teachers were indeed retreating to a very traditional model of instruction that limited student discourse. Teachers indicated that they didn’t feel they had the time to let them talk about it.

While at the same time, in an effort to be efficient in supporting the entire region, the majority of mathematics professional development offerings were provided in a face-to-face workshop format presented at the Region 10 ESC facility or at specific campuses. Some online courses and resources were offered, but enrollment was low and teachers reported preferences for in-person offerings. Services that included sustained and in-depth support described as important to professional development for mathematics teachers, like coaching and case studies, were only provided on a limited basis and included an extra fee.

Consequences for the Audience

Region 10 ESC professional development workshops, as they were designed, would not be successful in improving discourse ecology in light of the data presented earlier with the pressures mathematics teachers were experiencing while implementing new math standards. In an effort to increase the effectiveness of professional development, I proposed a professional learning follow-up intervention with a group of four middle-level mathematics teachers. Teachers who completed the 2013–2014 or 2014–2015 professional development workshops focused on student discourse were offered an opportunity to participate in a professional learning follow-up on discourse. The follow-up intervention consisted of four coaching sessions over several weeks. Sessions consisted of planning conversations and discussions of possible strategies, classroom observation of the implementation attempt, and a feedback discussion to support teacher reflection and growth. I proposed to study the experiences of the teachers participating in the short, sustained, and supportive follow-up to the typical Region 10 professional development workshop and note any changes in teacher beliefs and instructional behaviors related to discourse ecology. If the intervention showed promise for increasing teacher implementation of student discourse strategies, a similar follow-up program may increase the effectiveness of Region 10 ESC in providing support to campuses as it works to increase the implementation of other research-based strategies designed to improve its instructional programs. The results of this work were presented to Sally White and James Matthew as a proposal to integrate such a follow-up program as a new service offered to struggling teachers in the region for improving the discourse ecology and other research-based instructional strategies that support improving the excellence of schools within the region.

My Role

My role was to coordinate and provide the intervention, as well as analyze the effectiveness of providing a short, sustained, and in-depth coaching follow-up to typical Region 10 ESC professional development workshops. Results and conclusions were shared with other Region 10 ESC mathematics consultants and district leaders so that they might also benefit from examining the results of the data.

The Solution

The final proposed solution was the result of many conversations with stakeholders: struggling teachers, successful teachers, campus leadership, district leadership, Texas A&M professors, and Region 10 ESC consultants. Classroom observations and these informal conversations helped reframe the problem and its cultural perspective in order to arrive at the following intervention. It was with this data that I was able to take the problem from its original understanding that "teachers don't have the content and pedagogical knowledge" to "Region 10's workshop format for professional development is not as effective as hoped in making necessary changes to classroom instruction."

This reframing process provided a new understanding of the problem to be the gap between the intentions during professional development workshops and implementation of instructional changes in the classroom. Successful teachers and struggling teachers both expressed intentions to change instruction during professional learning workshops. The difference between successful and struggling teachers appeared after the workshop. Successful teachers began a process of implementation, reflection, and revision until they were successful in implementing the strategies of interest. Struggling teachers may have attempted implementation, but seemed to end the process prematurely without sufficient reflection and revision. They also reported being unable to access the additional information and/or support needed to feel successful in implementing the new strategies.

The final proposed solution was to expand the traditional workshop model of professional development on student discourse and incorporate an abbreviated and focused coaching intervention. This intervention was designed to provide struggling teachers the additional information and support they were missing in the change process. Specifically, the proposed intervention is to provide four sixth-grade teachers who had participated in a student discourse workshop with four follow-up coaching sessions. These sessions included planning, classroom observation, and feedback components that took place over several weeks. Anticipated favorable outcomes included teachers changing their actions to increase the quality of student discourse in their classroom instruction, as well as experiencing changed beliefs about student discourse as an instructional strategy. If we accomplish a change in teachers' actions and beliefs, then students may develop a deeper understanding of mathematics concepts. Data collection methods included classroom observations, teacher interviews, and teacher journal reflections. The research questions evolved from the goals of the intervention. Were there changes in teachers’ beliefs post-coaching intervention? Were there changes in teachers’ actions or abilities to facilitate student discourse in the mathematics classroom?

CHAPTER II

LITERATURE REVIEW

Theories

To understand what was missing in mathematics classrooms, one must first consider research literature focusing on how students learn mathematics. To understand the nature of learning, Bransford, Brown, and Cocking (2000) provided a solid foundation. Dominating my initial understanding of the problem was their conclusion that successful mathematics learning is dependent on "teachers' knowledge of mathematics, pedagogical content knowledge, and knowledge of students in general" (p. 171). In this constructivist approach, "all people, all of the time, construct or give meaning to things they perceive or think about" (Van de Walle, Karp, & Bay-Williams, 2013, p. 19). Bruton (1984) described how verbalizing mathematical thinking in a questioning atmosphere facilitates the development of mathematical thinking. Hiebert (1992) also discussed the cognitive psychological theories behind reflective thinking, drawing on work by Dewey to emphasize how important reflection and discourse are to the development of mathematical concepts. Hiebert stated, "Classroom discourse is essential for engaging students in mathematics" and "plays a significant role in learning mathematics," suggesting that students "construct knowledge and understanding working collaboratively that they would not develop working alone" (1992, p. 444). This seemed to be a critical component of pedagogical content knowledge that eluded mathematics teachers in the region.

With a focus on mathematical discourse, Herbel-Eisenmann and Cirillo (2009) conducted a two-year study of student discourse in a middle-grade classroom through action research. Results included descriptions of a series of reflections from classroom teachers about critical issues in the implementation of classroom discourse, the process and tensions in change, productive discourse, and selective listening. Hancewicz (2005), Kazemi (1998), Chapin, O'Connor, and Anderson (2009), Nichols (2014), Sherin (2000), and Omohundro Wedekind (2011) provided specific examples of how to facilitate effective discourse in mathematics classrooms and issues that may arise. All these sources informed professional development workshops created at Region 10 ESC with the purpose of increasing student discourse.

However, the Region 10 approach tended to neglect our understanding of what constitutes effective professional development. Darling-Hammond (1999) spoke out for effective professional learning as a key component for a successful educational system. Loucks-Horsley et al. (2010) and Joyce and Showers (2002) provided the guidebooks for effective professional development for mathematics teachers. Hull, Balka, and Miles (2009) provided the general goal of a mathematics coach. They also noted the coach's role in the change process by influencing "adults to cause change in their beliefs and actions" (p. 7). Lieberman, Hanson, and Gless (2012), Collet (2012), Hall and Simeral (2008), Knight (2012), Neuberger (2012), and a research brief from the National Council of Teachers of Mathematics (2013) also shared experiences, techniques, and information about the effectiveness of the coaching model. Hansen and Mathern (2008) described experiences of the administrator and mathematics coach at an elementary campus that focused on a "think-pair-share" intervention, which resulted in rich student discourse and increased test scores. This research helped clarify research questions about teacher struggles to implement the student discourse strategies presented by Region 10 in workshops and the choice of coaching as the intervention.

Relevant Literature

Problems of practice in education tend to be multifaceted and difficult to solve with a single action or intervention. Problems that persist over time, as the one presented in this proposal, require reframing and innovative solutions. Cuban (2001) suggested that "no-fault framing becomes an essential ingredient in stating problems that leave open a more generous range of alternatives to explore for a solution" (p. 9). Pascale et al. (2010) proposed considering the different actions of positive deviants to find innovative solutions. Identifying and considering the experiences of "successful" teachers provided insight into an appropriate intervention designed to help unsuccessful teachers. In addition, the backward design of thought dictates that in order to bring about change in student performance, there must be change in the activities in which students engage in the classroom. In order to adjust these activities, teachers' actions and planning must change (Barkley & Bianco, 2009). This thinking led to the conclusion that to bring about change in student performance, the actions of Region 10 ESC in providing professional learning support needed to be amended.

Qualitative methods described by Creswell (2013) and Denzin and Lincoln (2011) were critical in the approach to reframing the problem by understanding the values of stakeholders, as well as the plan to document potential changes brought about by the proposed intervention. Understanding the experiences of both successful and struggling teachers informed the problem framing and the proposed solutions. In addition, qualitative methods appeared essential in understanding the experiences of the participating teachers. Program evaluation methods shared by Fitzpatrick, Sanders, and Worthen (2011) aided in creating a theory-based evaluation approach. In addition to Herbel-Eisenmann and Cirillo (2009), qualitative studies of the experiences of teachers and researchers reported by Brantlinger (2014), Tanner and Jones (2000), and Williams and Baxter (1996) provided clarity on the proposed methods and potential issues with validity. Hufferd-Ackles et al. (2004), Herbel-Eisnemann and Otten (2011), Piccolo, Harabaugh, Carter, Capraro, and Capraro (2008), Mendez et al. (2007), Chen and Herbst (2013), and Jackson, Garrison, Wilson, Gibbons, and Shahan (2013) provided examples of quantitative measures, mappings, and rubrics by which to assess the quality and quantity of student discourse. Of these, the most applicable for use in observing teachers in my study proved to be the classroom observation rubric in Hufferd-Ackles et al. (2004) describing the relative levels of math-talk community, the RMD framework from Mendez et al. (2007), and the Dynamic Student Teacher Communication Pathways (DSTCPs) from Piccolo et al. (2008). Marshall (2013) developed a rubric to use in science and mathematics classroom observations to determine the level of inquiry, which was validated by Marshall, Smart, and Horton (2009). Discussions with the department chair, as well as Dr. Marshall via e-mail correspondence, supported the use of the rubric’s instructional and discourse factors in the methods.

Most Significant Research and Practice Studies

An extensive review of the literature continued to be a source of clarification and inspiration, both for framing and reframing problems and exploring potential solutions. The most significant research studies located in forming theories described previously are listed in the table in Appendix A.

Significance of the Literature Review

By conducting the literature review and the associated exercises in the second internship, I found a new way of viewing the problem I had wrestled with for almost two years since joining Region 10 ESC. Cuban (2001) and Barkley and Bianco (2009) paved the way for a more critical examination of multiple aspects of the problem, including understanding stakeholder values, competing values, and our role as leaders in education. The literature on how children learn mathematics helped clarify my constructivist view and identify the differences between what I believed about how children learned mathematics and what I observed in mathematics classrooms. The literature on effective professional development combined with the positive deviance approach provided guidance in defining the vision of the ideal situation, as well as possible solutions, and provided the focus for my assessment of its effectiveness. Finally, mathematics discourse literature and research methodologies focused my approach for this proposed study and provided critical measures used to quantify and qualify student discourse during analysis of classroom observations.

CHAPTER III

METHODS

Statement Regarding Human Subjects and the Institutional Review Board

A preliminary review of the methods for collecting information from human subjects determined that the methods proposed for this study did not meet the federal definition of "human subject research with generalizable results." As the proposed information-gathering methods were within the general scope of activities and responsibilities associated with my current position, I was not required to seek human subject approval. Please see Appendix B, which is a copy of the e-mail communication regarding the Institutional Review Board (IRB) decision about the study.

Research Questions

In order to understand the possible impact and potential effectiveness of intervention, the following research questions were investigated:

1. Were there changes in four middle-school teachers' beliefs post-coaching intervention—specifically, how did their beliefs change about student discourse and their role as a teacher in facilitating student discourse?
2. Were there changes in teachers' abilities to facilitate student discourse in the mathematics classroom?

Goals, Objectives, and Activities

The goals for the intervention were to affect change in teacher beliefs and the level of discourse ecology in the classroom. Discourse ecology is defined as a mathematics teacher's use of instructional strategies to facilitate increased student discourse designed to enhance students' conceptual understanding of mathematics. The intervention approach was created based on a coaching model (Loucks-Horsley et al., 2010) supported by literature as an effective professional learning approach to support mathematics teachers during the change process. While the desired outcome is an increase in discourse ecology, it will also be interesting to understand how teacher beliefs also change during the process. Specifically, I proposed the following two goals:

I. Teachers will exhibit changed beliefs about student discourse, their role as a teacher, and their capacity for facilitating student discourse.

II. Teachers will demonstrate an increased ability to facilitate effective student discourse in their mathematics classrooms—improved discourse ecology.

In order to achieve these goals, objectives and activities were identified and are listed in Table 2. The objectives were specific, measurable, and time-bound. The activities listed for each goal were the actions the teachers and I took to meet the objectives and achieve the goals. Table 3 includes the assessments for each of the objectives.

Table 2

Goals, Objectives, and Activities Associated with the Problem Solution

Goal	Objective	Activity
I. Changing Beliefs Teachers will exhibit changed beliefs about student discourse and their capacity to enhance students' discourse in mathematics.	A. Participating teachers will report change in their beliefs about the value of student discourse in mathematics by the end of the intervention. B. Participating teachers will report change in their beliefs about their role as a teacher or about their capacity to implement changes in students' mathematical discourse by the end of the intervention.	1. Teachers and coach will participate in four coaching sessions each (total of 16 sessions for coach) that include planning, observations, and feedback designed to support teachers in the change process. a) Coach will support teachers in planning how to implement new strategies to facilitate student discourse. b) Coach will observe and document classroom discourse to gather data for feedback. c) Coach will support changes in teacher actions by providing feedback and suggestions when reviewing data from classroom observations.
II. Changing Actions Teachers will demonstrate an increased ability to facilitate effective student discourse in their mathematics classrooms—improved discourse ecology.	A. Mathematics discourse in observed classes will reflect higher levels of questioning—specifically questioning level, questioning complexity, and questioning ecology—and student-centered communication patterns. B. Mathematics discussions in classes observed will demonstrate an increased cognitive level, as indicated by the type of questions and answers students share as measured by level of Blooms Taxonomy. C. Teachers in observed classes will demonstrate actions that result in classroom interactions supporting deep conceptual understanding of mathematics by facilitating student exploration requiring students to provide evidence and share reasoning through discourse.	2. Outside the coaching sessions, teachers will reflect about their experiences and beliefs during the intervention and share with the coach.

Table 3

Goals, Objectives, Activities, and Assessments Associated with the Problem Solution

Goal	Objective	Activity
<u>I. Changing Beliefs</u> Teachers will exhibit changed beliefs about student discourse and their capacity to enhance students’ discourse in mathematics.	A. Participating teachers will report a change in their beliefs about the value of student discourse in mathematics by the end of the intervention. B. Participating teachers will report change in their beliefs about their role as a teacher or about their capacity to implement changes in students’ mathematical discourse by the end of the intervention.	1. Teachers and coach will participate in four coaching sessions each (total of 16 sessions for coach) that include planning, observations, and feedback designed to support teachers in the change process. a) Coach will support teachers in planning how to implement new strategies to facilitate student discourse.
<u>II. Changing Actions</u> Teachers will demonstrate an increased ability to facilitate effective student discourse in their mathematics classrooms—discourse ecology.	A. Mathematics discourse in observed classes will reflect higher levels of questioning—specifically questioning level, questioning complexity, and questioning ecology—and student-centered communication patterns. B. Mathematics discussions in classes observed will demonstrate an increased cognitive level. C. Teachers in observed classes will demonstrate actions that support deep conceptual understanding of mathematics by facilitating student exploration that requires students to provide evidence and share reasoning through discourse.	b) Coach will observe and document classroom discourse to gather data for feedback. c) Coach will support changes in teacher actions by providing feedback and suggestions when reviewing data from classroom observations. 2. Outside the coaching sessions, teachers will reflect about their experiences and beliefs during the intervention and share with the coach. • <u>*IA, IB*</u>*: Teacher reflection artifacts related to changing beliefs, teacher comments during planning and feedback sessions about changing beliefs, teacher responses about changes in beliefs about student discourse and their roles (Herbel-Eisenmann & Cirillo, 2009, p. 6, 16), capacity to facilitate student discourse (“How do you feel*

Table 3 *(Continued)*

Goal	Objective	Activity
		about your ability to implement strategies presented in professional development workshops?") • *IIA: Use Marshall (2013) EQUIP V Discourse Factors D1–D5* • *IIB: Use Hufferd-Ackles et al. (2004) Levels of Math Talk Learning Community Rubric (p. 88–90) to measure levels of student discourse analysis over successive classroom observations to indicate an increase in the effectiveness of the discourse.* • *IIC: Use Marshall (2013) IV Instructional Factors I1–I5.*

Instruments and Analysis

The research questions focused on the two goals for the intervention: changing teachers' beliefs and changing teachers' actions as related to students' construction of mathematical ideas using discourse strategies. The first research question was "How effective was the coaching experience in terms of affecting changes in teachers' beliefs—specifically about student discourse, their roles as teachers, and their capacity to facilitate student discourse?". To answer this question, there were three pairs of guiding questions, one about each of the beliefs. The first in each pair attempted to establish a baseline understanding of teachers' beliefs during the initial planning session and through teacher reflection. The second in each pair attempted to monitor teachers' beliefs throughout the intervention period in order to detect any changes. These data came from the planning/feedback session notes and teacher reflections. The second research question related to changes in teachers' actions resulting in increased discourse ecology in the classroom. Tables 4 and 5 contain each of the guiding questions, the data collection methods, and the rationale for each choice.

Table 4

Guiding Questions, Data Collection Methods, and Rationale for Methods Leading to Conclusions About the Success of the Problem Solution with Goal I, Research Question 1

Guiding Questions	Data Collection Methods	Rationale for Methods
1a. What beliefs did teachers express about the effectiveness of student discourse in improving student learning during the initial planning sessions?	Planning session audio recordings and field notes	Documenting teachers' expressions of beliefs related to the efficacy of student discourse provided a baseline for comparison of beliefs expressed later in the intervention (Herbel-Eisenmann & Cirillo, 2009, p. 6).
1b. How did teachers' beliefs about the effectiveness of student discourse in improving student learning change during the intervention?	Teacher journal artifacts and planning/feedback session audio recordings	Data from initial and subsequent meetings were compared to assess changes in teachers' beliefs.
2a. What beliefs did teachers express about their capacity to facilitate student discourse during the initial planning sessions?	Planning session audio recordings and field notes	Documenting teachers' expressions of beliefs related to their capacity to facilitate student discourse provided a baseline for comparison to beliefs expressed later in the intervention. ("How do you feel about your ability to implement strategies presented in professional development workshops?")
2b. How did teachers' beliefs about their capacity to facilitate student discourse change during the intervention?	Teacher journal artifacts and planning/feedback session audio recordings	Data from initial and subsequent meetings were compared to assess changes in teachers' beliefs.

Table 5

Guiding Questions, Data Collection Methods, and Rationale for Methods Leading to Conclusions About the Success of the Problem Solution with Goal II, Research Question 2

Guiding Questions	Data Collection Methods	Rationale for Methods
1. During the intervention, how does the level of questioning and communication pattern change in observed classes?	Classroom audio recording and field notes Marshall (2013) EQUIP Levels IV and V	To understand how teachers progress toward facilitating higher levels of discourse ecology, each observed lesson segment was scored on Marshall's (2013) IIM instruction and discourse factors focusing on discourse and questioning patterns—who is talking and discourse strategies employed. [Marshall's (2013) EQUIP IV I1, I3, I4, V D1, D2, D3, and D4 were quantified and compared based on a percentage of instructional time at each level.]
2. What changes were noted during the intervention in the cognitive level of students' mathematics talk in the classroom?	Classroom observation audio recordings, observation field notes Hufferd-Ackles et al. (2004) Levels of Math Talk Learning Community Instrument	To understand if there is an increase in the level of rigor of mathematical discussions in the classroom, each observation was compared based on the relative level of rigor. Hufferd-Ackles et al. (2004) Levels of Math Talk Learning Community Instrument provides a measure of the relative level of rigor and effectiveness of the student discourse in a mathematics classroom.
3. How did the teachers' actions result in an increased depth of conceptual understanding of mathematics?	Classroom audio recording and field notes Marshall (2013) EQUIP Levels IV and V	To understand how teacher actions support deep conceptual exploration of mathematical concepts, each observed lesson segment was scored on Marshall's (2013) IIM instruction and discourse factors focusing on the depth of student conceptual explorations and discussions. [Marshall's (2013) EQUIP IV I2, I5, and D5 will be quantified and compared based on a percentage of instructional time at each level.]

Recruitment

After the committee approved the Record of Study (ROS) proposal, I contacted several teachers at various schools in Region 10. One sixth-grade campus expressed a desire to participate together. I chose four teachers at the same sixth-grade campus. In this way I was working with teachers who all were teaching at the same grade level and on the same campus in the same district. Participants were Mr. Kaye, Mr. Waters, Ms. Anderson, and Ms. French (fictitious names). Each teacher was observed teaching one lesson on four separate occasions. I observed the classes during the same class period in an attempt to keep students constant across the observations over time. Mr. Kaye and Mr. Waters were observed during the campus Blitz Blocks (three 65-minute blocks of time in the morning for six weeks for focused review prior to the state test). Ms. Anderson and Ms. French were observed during afternoon classes, which were regular 44-minute class periods. Due to teacher absences, a make-up observation day was included in addition to the original four scheduled in order to have four observations for each teacher. The observation days consisted of observation and recording of the identified classes, brief feedback between class periods, and, on two occasions, Professional Learning Community (PLC) sessions.

Southeast STEM Center (a fictitious name) is a sixth-grade-only campus located within a small school district (just over 6,500 students) outside a large urban area. The city has reported its population to be less than 38,000, with approximately 69% African-American, 20% White, and 17% Hispanic. Similar demographics were reported by the state for the Southeast STEM Center campus. Of the 463 students enrolled in 2014, 76%

were identified as African-American, 3% as White, and 20% as Hispanic/Latino. The campus is a Title I campus, with 86% of students identified by the state as economically disadvantaged and 43% as at-risk. (A variety of indicators is used by the state to determine if a student is at risk of not graduating. These include failure to pass previous-grade-level standardized exams.) During the year prior to intervention, 66% of the students at the campus passed the sixth-grade state mathematics assessment (compared with 79% in the state and 80% in the region).

The campus mathematics instructional coach organized the intervention schedule on her campus and ensured that all her teachers had received face-to-face or online *Student Talk = Math Success* professional development. Four teachers volunteered to participate in the coaching intervention at the campus: Mr. Kaye, Mr. Waters, Ms. Anderson, and Ms. French. In addition, some other mathematics teachers participated in PLC meetings and asked questions.

Instruments

The two research questions were considered using instruments from literature. The data gathered were considered separately for each teacher participant. These data were analyzed according to the theme of ‘change over time” for each of the teachers. The data were then represented using an ‘in-depth portrait of the cases,” as described in Creswell (2013, p. 209). This analysis was used to describe the experiences of the four teachers during the intervention and discuss similarities and differences in changes in beliefs and actions. Gathered data and artifacts included

- audio recordings of whole-group discussions and some recordings of small-group recordings
- observer field notes recorded during observations
- PLC audio recordings and transcripts
- written feedback from the observer communicated to teachers delivered in person or via e-mail
- reflections written by teachers delivered in person, via e-mail, or via Google forms.

Using these data, the following analyses were conducted. A case study for each teacher was generated answering both research questions. The case studies were organized with teacher background information and pre-intervention belief discussions at the beginning. Next, a chronological analysis of discourse ecology in observed lessons was conducted. Finally, post-intervention beliefs were analyzed.

Changes in Teacher Beliefs

In order to understand their beliefs, teachers were asked to consider questions before and after the coaching intervention. To identify teachers' beliefs about the efficacy of student discourse in facilitating students' conceptual understanding of mathematics, the following reflection questions from Herbel-Eisenmann and Cirillo (2009) were asked:

- What does the word discourse mean to you? What might be some reasons for you to increase your awareness of the patterns in your own classroom discourse?

- As a classroom teacher, what currently is your interaction with students? How much do you talk? How much do students talk? Who talks more?
- How are you helping students gain skills in speaking, reading, writing, and listening to mathematics? (p. 6)

In order to understand teachers' beliefs about their roles in the classroom during instruction and discourse, they were asked to reflect and respond to the following questions from Herbel-Eisenmann and Cirillo (2009):

- What kinds of experience do you think are important for your students to have in your classroom? What kinds of expectations do you have for your students?
- What are some of the roles you play in the classroom, and why do you think those roles are important? What are some of the roles that students play in your classroom, and why do you think those are important? (p. 16)

Finally, in order to understand teachers' beliefs about their capacity to implement instructional change in the classroom, they were asked to reflect on this author-created question: "How do you feel about your ability to implement strategies presented in professional development workshops?"

Teacher feedback artifacts and recordings and analyses of teacher lessons were considered separately and together to identify changes in teacher beliefs related to discourse. These perceived changes in beliefs were then considered over time in an attempt to describe how teachers may have responded to the coaching intervention. Any identifiable changes were noted in teacher beliefs related to the importance of discourse in students learning mathematics or in their abilities to facilitate student discourse.

Changes in Teachers' Actions

To understand the changes occurring during the intervention focused on teachers' actions, lesson segments were scored through the use of audio recordings of observed lessons. Two instruments were used to identify perceptible changes in teacher actions resulting in an increase in discourse ecology. First, lesson segments were identified during the lesson observation. A lesson segment is defined from the student perspective—when they are invited to participate in a different way. For example, a lesson segment might be students listening to announcements and housekeeping information, students checking homework, students listening to a lecture and taking notes, or students working in groups on an assignment. The lesson segments may have reduced primacy and recency effects (Mashburn, Meyer, Allen, & Pianta, 2014).

Measuring discourse ecology of observed lessons

Over the course of the four observations, I recorded and reviewed the discourse in the classroom. As Stein (2007) stated, "Mathematics classroom discourse is a dynamic process" (p. 288), which led me to using the Hufferd-Ackles et al. (2004) Math Talk Community as a framework to describe and evaluate the discourse. The framework describes four dimensions of discourse ecology: questioning, explaining mathematical thinking, source of mathematical ideas, and responsibility for learning. *Questioning* describes the transition from a traditional teacher-questioning mode to students and teachers sharing the responsibility for questioning. *Explaining mathematical thinking* describes the transition from teacher as lecturer/explainer to students explaining their ideas. *Source of mathematical ideas* describes the transition from teacher as owner and deliverer of mathematical ideas to students sharing their ideas and directing the discourse. Finally, *responsibility for learning* describes the growth in student responsibility from passive learner to engaged constructor of knowledge by listening to other students' ideas and comparing those shared with their own conceptual understandings.

Preliminary analysis of lessons

This analysis consisted of using written field notes and recordings; the observer separated each lesson into segments. The segments were determined based on student perspectives of what their task was in the classroom. For example, many lessons began with students entering the rooms and finding their seats. Next, students were asked to complete a bell-ringer warm-up problem, after which they participated in a whole-group review of the warm-up and then may have participated in a whole-group review of a prior assignment or were assigned to computers. The duration of each of these segments was recorded, and a percentage of each observed portion of the lesson was calculated. Next, each segment was reviewed to identify communication patterns. For example, some segments exhibited a very didactic, teacher-controlled communication pattern in which the teacher walked the students through solving a problem by asking low-level closed questions. Other segments were small-group, student-directed conversations about problems. After identifying patterns of communication, each segment was rated using the Hufferd-Ackles et al. (2004) Math Talk Community rubric, and this information provided feedback to teachers using observer comments and suggestions. This Math Talk Community rubric was shared during the PLC or via e-mail with teachers.

In an effort to reduce rater drift, a “gold standard” analysis was performed using a published exemplar of student discourse from Hancewicz (2005, p. 73–74). In addition, intra-rater reliability concerns were addressed as recordings of all the observed lessons, and associated field notes of the observed lessons were reviewed a third time after several weeks to provide for a fresh perspective on the lesson. During this final review, the lessons were taken out of strict chronological order and were reviewed on a teacher-by-teacher basis. Each teacher’s lessons were reviewed sequentially before another teacher’s lessons were reviewed. In an attempt to reset and diminish the influence from one teacher’s lessons to the next on the ratings, the published exemplar and rubrics were reviewed again before proceeding to review the next teacher. The reviews took place with several days between each of them. These scores were then used as an indicator of changes in teachers’ actions in facilitating student discourse.

Weighted comparisons of rubric scores

Each observed lesson was divided into segments delineated by changes in student behaviors. For each segment, the level of Math Talk Community was determined by comparing the nature of the observed discussion to the characteristics described in the Hufferd-Ackles et al. (2004) Math Talk Community rubric (Table 6) and the Marshall (2013) Instructional Factors and Discourse Factors rubrics.

Table 6

Math Talk Learning Community (Adapted from Hufferd-Ackles et al., 2004, p. 88–90)

Level	Questioning	Explaining Mathematical Thinking	Sources of Mathematical Ideas	Responsibility for Learning
1	Teacher is the only questioner. Short frequent questions function to keep students listening and paying attention to the teacher.	No or minimal teacher elicitation of student thinking, strategies, or explanations; teacher expects answer-focused responses. Teacher may tell answers.	Teacher is physically at the board, usually chalk in hand, telling and showing students how to do math.	Teacher repeats student responses for the class. Teacher responds to students' answers by verifying the correct answer or showing the correct method.
2	Teacher questions begin to focus on student thinking and focus less on answers. Teacher begins to ask follow-up questions about student methods and answers. Teacher is still the only questioner.	Teacher probes student thinking somewhat. One or two strategies may be elicited. Teacher may fill in explanations herself.	Teacher is still the main source of ideas, though she elicits some student ideas. Teacher does some probing to access student ideas.	Teacher begins to set up structures to facilitate student listening to and helping other students. Teacher alone gives feedback.
3	Teacher continues to ask probing questions and also asks more open questions. She also facilitates student-to-student talk.	Teacher probes more deeply to learn about student thinking and support detailed descriptions from students. Teacher is open to and elicits multiple strategies.	Teacher follows up on explanations and builds on them by asking students to compare and contrast them. Teacher is comfortable using student errors as opportunities for learning.	Teacher encourages student responsibility for understanding the mathematical ideas of others. Teacher asks other students questions about student work and whether they agree or disagree and why.
4	Teacher expects students to ask one another questions about their work. The teacher's questions still may guide the discourse.	Teacher follows along closely to student description of their thinking, encouraging students to make their explanations more complete. Teacher stimulates students to think more deeply about strategies.	Teacher allows for interruptions from students during her explanations; she lets student explain and "own" new strategies. Teacher uses student ideas and methods as the basis for lessons.	Teacher expects students to be responsible for co-evaluation of everyone's work and thinking. Teacher supports students as they help one another sort out misconceptions. Teacher helps and/or follows up when needed.

The instructional segments for each lesson were labeled according to whether student discourse was an intended action for students. Segments that did not include student discourse were labeled not applicable. For example, many lessons began with a warm-up activity the students were to complete individually—not applicable. The next segment might be a whole-group discussion about the warm-up—applicable. The class might then transition to another activity, which was noted as a transition time—not applicable. All applicable segments were rated and the scores recorded. The duration of each of the applicable segments were added together. This total was used to determine the percentage of each of the applicable segments. Weighted scores across the applicable segments were calculated by multiplying individual segment scores by the percentage of that segment. For example, if during half the time student discourse was measured at Level 2 and during the other half they were talking at a measured as Level 3, then the weighted score would be 2.5 as measured for the entire lesson. These measured scores were displayed using a bar graph for each lesson. The scores from the individual segments and these weighted averages of Math Talk Community indicators were graphed as a summary and provided to teachers as feedback.

In a similar way, Marshall's (2013) instructional and discourse factors were recorded for each segment and summarized with a weighted average. Marshall et al. (2009) described four categories of "performance indicators that teachers can control that influence student achievement"—instruction, discourse, assessment, and curriculum (p. 83). The first two categories of performance indicators were used to describe how the teachers' actions related to discourse ecology changed over the intervention. Marshall's rubric provides a measure of each of the indicators from Level 1 to the exemplary Level 4. The instructional factors category addresses how a teacher facilitates learning.

Marshall (2013) identified five instructional factors that affect discourse ecology: instructional strategies, order of instruction, teacher role, student role, and knowledge acquisition (Table 7). The *instructional strategies* indicator measures the transition of teacher as lecturer-covering-content to teacher as facilitator-of activities-that-engage-students-and-develop–strong-conceptual-understandings. The *order of instruction* indicator measures the continuum from teachers explaining concepts to students without prior exploration to full inquiry mode, in which students explore the concept and created their own understanding of the concepts. The *teacher role* and *student role* indicators are complementary and range from the teacher as the center of the lesson and students as passive learners to teachers as facilitators and students consistently and actively engaged throughout the lesson. The *knowledge acquisition* indicator measures the final instructional factor described. This indicator measures the level of knowledge acquisition from low-level mastery of facts and rote processes to deep understanding relating content and process skills.

Table 7

Instructional Factors (Adapted from Marshall et al.,2009 p. 314–315)

Level	1	2	3	4
Instructional Strategies	Teacher predominantly lectured to cover content.	Teacher frequently lectured and/or used demonstrations to explain content. Activities were verification only.	Teacher occasionally lectured, but students were engaged in activities that helped develop conceptual understanding.	Teacher occasionally lectured, but students were engaged in investigations that promoted strong conceptual understanding.
Order of Instruction	Teacher explained concepts. Student either did not explore concepts or did so only after explanation.	Teacher asked students to explore concept before receiving explanation. Teacher explained.	Teacher asked students to explore before explanation. Teacher and students explained.	Teacher asked students to explore concept before explanation occurred. Though perhaps prompted by teacher, students provided explanation.
Teacher Role	Teacher was center of lesson; rarely acted as facilitator.	Teacher was the center of lesson; occasionally acted as facilitator.	Teacher frequently acted as facilitator.	Teacher consistently and effectively acted as a facilitator.
Student Role	Students were consistently passive as learners.	Students were active to a small extent as learners (highly engaged for very brief moments or to a small extent throughout lesson).	Students were active as learners (involved in discussions, investigation, or activities, but not consistently and clearly focused).	Students were consistently and effectively active as learners (highly engaged at multiple points during lesson and clearly focused on task.)
Knowledge Acquisition	Student learning focused solely on mastery of facts, information, and/or rote processes.	Student learning focused on mastery of facts and process skills without much focus on understanding of content.	Student learning required application of concepts and process skills in new situations.	Student learning required depth of understanding to be demonstrated relating to content and process skills.

Marshall's (2013) discourse indicators (Table 8) describe the type of questioning and communication patterns and student interactions that the teachers implemented and facilitated in their lessons. The *questioning* indicator addresses the cognitive level of questions during the lessons. For example, Level 1 *questioning* describes teacher questioning at the remembering cognitive level, while Level 4 characterizes teacher questioning that challenges students at a variety of levels to scaffold learning up to the analysis level or higher. The *complexity of questions* indicator describes questioning from short, correct answer responses to open-ended questions requiring students to explain, reason, or justify their solutions. It also includes students evaluating other students' responses. The *questioning ecology* indicator addresses the ability of the teacher to engage students in discussions. The *communication pattern* indicator reflects who controls the conversation. Level 1 communication pattern is teacher-controlled and follows a didactic pattern. Level 4 reflects a conversational pattern, with student questions guiding the discussion. *Classroom interaction* is a discourse ecology indicator of the quality of follow-up after students respond to questions. Level 1 reflects the teacher accepting answers from students, with correction as needed. As the indicators increase in level, who follows up and how they follow up changed from teacher-focused to student-focused. Students may request clarification and justifications to the point at Level 4, where the teacher is the facilitator and students question each other and discuss.

Table 8

Discourse Factors (Adapted from Marshall et al., 2009, p. 315–316)

Level	1	2	3	4
Questioning Level	Questioning rarely challenged students above the remembering level.	Questioning rarely challenged students above the understanding level.	Questioning challenged student up to application or analysis levels.	Questioning challenged students at various levels, including at the analysis level or higher; level was varied to scaffold learning.
Complexity of Questions	Questions focused on one correct answer; typically short answer responses.	Questions focused mostly on one correct answer; some open-response opportunities.	Questions challenged students to explain, reason, and/or justify.	Questions required student to explain, reason, and/or justify. Students were expected to critique others' responses.
Questioning Ecology	Teacher lectured or engaged students in oral questioning that did not lead to discussion.	Teacher occasionally attempted to engage students in discussion or investigations, but was not successful.	Teacher successfully engaged students in open-ended questions, discussions, and/or investigations.	Teacher consistently and effectively engaged students in open-ended questions, discussion, investigations, and/or reflections.
Communication Pattern	Communication was controlled and directed by the teacher and followed a didactic pattern.	Communication was typically controlled and directed by the teacher with occasional input from other students; mostly didactic pattern.	Communication was often conversational, with some student questions guiding the discussion.	Communication was consistently conversational, with student questions often guiding the discussion.
Classroom Interaction	Teacher accepted answers, correcting when necessary, but rarely followed up with further probing.	Teacher or another student occasionally followed up student response with further low-level probing questions.	Teacher or another student often followed up responses with engaging probing that required student to justify reasoning or evidence.	Teacher consistently and effectively facilitated rich classroom dialogue where evidence, assumptions, and reasoning were challenged by the teacher or other students.

Longitudinal behavior analysis by teacher

Recordings and field notes of the observed lessons were reviewed again, along with preliminary analysis of and weighted comparisons of rubric scores to determine how observable teacher actions changed over the course of the coaching intervention related to facilitating student discourse (research question 2). Each category of discourse ecology from the Math Talk Community rubric and the Marshall (2013) instructional and discourse factors were aggregated in tables and line graphs. Each table and accompanying graph was analyzed for discernible patterns of changes in teacher and student actions related to student discourse in the mathematics classroom.

Comprehensive analysis for each teacher and across teachers

For each of the four teachers, longitudinal teacher behavior analysis and longitudinal teacher belief analysis were used to describe observable changes in teacher actions combined with stated beliefs. A brief analysis across the teachers was conducted. The purpose was to identify any discernible patterns of impact of the intervention. A second purpose for the consideration of each of the teacher case studies was an attempt to understand which teachers benefited from the intervention.

Issues of Reliability, Validity, Confidentiality, and Other Ethical Concerns

Threats to reliability and validity in this proposed multi-case study stem from the potentially very different contexts and teachers who will be participating. The teachers who responded and were included in the case study have very different personal and professional histories that impacted their beliefs about their abilities and their capacity for change. The teachers who participated in this study did so because they responded to an offer for professional learning, but it was not clear if they truly understood what the intervention included until it was discussed during the initial meeting. Because they were not clear about the intervention and its goals, they were reassured that they could withdraw from the study if they chose. The initiative shown by teachers to respond to the offer may indicate a more advanced desire for making an instructional change than teachers who did not. The results may not be similar in situations where teachers are assigned to an intervention or forced to participate. Finally, results may not be applicable to other professional development topics.

Confidentiality of all involved in the study was maintained through a coding system and the use of fictitious names, whose key was kept on paper secured at a private residence. As with any field study, there were concerns about power. This study was designed to provide teachers power and voice in choosing to participate in the intervention with an option to opt out at any time. I continually assured them of confidentiality of our discussions, their reflections, and what occurred during classroom observations. None of this information was shared with their supervisors per Region 10 ESC policy.

CHAPTER IV

ANALYSES

The Case of Mr. Kaye

Background

Mr. Kaye was a computer lab teacher at Southeast STEM Center with a teaching role of computer lab instructor. However, he also had mathematics teaching experience; because of this, he was drafted to assist in the morning STAAR Blitz sessions. He was responsible for three different groups of mid-level-performing sixth-grade students. The four sessions I observed in his classroom were with his Blitz Block B students from March 19 to April 16, 2015.

Mr. Kaye is a White male teacher in his early 30s with several years of experience teaching elementary prior to joining the campus in the intervention year as a sixth-grade computer lab teacher. Mr. Kaye displayed effective classroom management skills and an ability to create a positive climate of respect and desire for learning in the students that I did not observe in other classes I visited on the campus. His management of transitions was particularly impressive, as well as his ability to conduct a whole-group discussion with half the class while monitoring other students working on computers. There were 18 students in the Blitz Block B I observed: 13 African-American students (seven girls, six boys), four Latino students (three girls, one boy), and one White student (girl).

Prior to meeting with Mr. Kaye for this coaching intervention, I had been to the district in January 2015 and conducted in-service teacher professional development, which Mr. Kaye had attended. Mr. Kaye had also completed the *Online Student Talk = Math Success* course in February 2015. In his responses to the pre-coaching intervention reflection questions, he indicated that while he had training on student discourse, he had not used the techniques in his classroom.

Pre-Intervention Perceptions and Beliefs

In his responses to the pre-coaching intervention beliefs survey, Mr. Kaye described discourse as "conversation/discussion about something meaningful." He indicated that he believed that in academic discussions there may even be disagreement that leads to consensus. He also expressed the belief that those who do the talking do the learning and how his students need to talk so that they can hear from others and create their own understanding about mathematical concepts. He admitted that they might even "tune out" when he is talking. He indicated the importance for his students to have discourse in which they disagree in a respectful way, explain their thinking, and explore new patterns that lead to generalizing mathematical concepts. However, he also indicated awareness that he talks more than his students in class. He stated that he was not doing much to support his students in gaining skills in speaking, reading, writing, and listening to mathematics.

Individual Lesson Observations, Discussion, and Scoring

Observation 1: March 19, 2015 / STAAR Blitz block B

General observations

Mr. Kaye taught in a room with a portion dedicated to student desktop computers and a portion designed for whole-group discussion, complete with tables, chairs, projector, and whiteboard. The class began with a bell-ringer warm-up problem for the whole group to individually work on decimal multiplication questions as students came in and got settled for the 65-minute block. After a few minutes, Mr. Kaye reviewed the bell ringer by having individual students go up to the whiteboard and write their multiplication process and the results. Mr. Kaye corrected an incorrect answer due to decimal placement. He then directed about half the class to go to the computers, log in, and begin working on a mathematics program. The remainder of the class stayed in their seats and worked three ratio/rate problems with Mr. Kaye in a whole-group discussion format. This first rotation lasted about 25 minutes. After the first two problems, Mr. Kaye took two minutes for a ”brain break,” in which students stood, stretched, and performed some dexterity exercises. Mr. Kaye then directed the students to switch places—the computer group returned to the tables and the group at the tables that had just completed the three problems went to the computers. The second rotation was similar to the first, with a group of students working on the computer program and the other group working together in whole-group discussion format to complete three problems. A minute or two before the end of the block, Mr. Kaye had the class reconvene together, clean up, and turn in work.

The learning segments that did not include student discourse were coded as not applicable. These segments included when students were working silently on the bell-ringer warm-up and during class transitions when students were moving from one location or group to another.

During the bell-ringer review, Mr. Kaye chose students to write their multiplication work on the whiteboard. Once they were finished, Mr. Kaye verified the correct answer and probed at a low level:

Mr. Kaye: What if it was 23.2 times 1.4? What would that do to the placement of the decimal in the product? Kathy?

Kathy: It would move it up one.

Mr. Kaye: When you say move it up one, what do you mean?

Kathy: Like instead of doing one you would do two.

Mr. Kaye: So she’s saying to move in twice this way? [Points to the right.] Okay so how do I know that? What about my factors tell me that I am going to move my decimal twice?

Student: Because you, from the first number you know one and the other one is one.

Mr. Kaye: Okay. Good. So we move it out here. That’s one place after the decimal, one place after the decimal, for a total of how many places past the decimal in the product?

Students: Two.

Mr. Kaye: So two places after the decimal in the product. Yes, so the multiplication doesn’t change, it is just the decimal placement that changes.

While Mr. Kaye asked Kathy to clarify her statement, he did not ask her for the reasoning behind her statement. He asked the class why her statement was correct, and another student offered a cryptic explanation, which Mr. Kaye took for correct, added to the student explanation, and asked students to add the number of times he moved the decimal for a sum of two. The bell-ringer review segment demonstrated Mr. Kaye beginning to pursue student thinking by asking an extension question and following up Kathy’s response with a ”How do I know?” question. Using Hufferd-Ackles et al. (2004) Math Talk Community rubric, this segment was scored at Level 2 because Mr. Kaye was beginning to focus on student thinking related to decimal placement, and he did probe for a strategy. However, he was still the main source of ideas, even though by asking students to present their work on the board, he was beginning to set up a structure for students to review other students’ work. A score of Level 2 was recorded for each of the Math Talk Community indicators for the bell-ringer review segment.

During the guided practice segments, Mr. Kaye was the only questioner—using the lowest level of *questioning*. His questions were simple and closed and required single-word responses, like in the following sequence:

Mr. Kaye: So what units are given in this problem?

Students: Quarts.

Mr. Kaye: And what units are in the answer choices?

Students: Cups.

Mr. Kaye: So what do we have to do to the quarts to make them cups?

Students: Convert them.

There was some evidence that the teacher probed student thinking when he asked about decimal placement in the bell-ringer review and when a student offered a shortcut in computations, but for the most part Mr. Kaye determined the solution strategy, asked all the questions, and verified any responses required for the problems. One such example was during the guided practice when Mr. Kaye was demonstrating how to fill in a table of values. This was one of the only times Mr. Kaye asked a student for a strategy:

Mr. Kaye: If I had two tons of material to recycle, how many pounds is that?

Students: 2,000.

Mr. Kaye: [Records 2,000 in the table under pounds.]

Mr. Kaye: If I have three tons of recycling, how many pounds is that?

Students: 6,000.

Mr. Kaye: So I am looking at this and I already see a pattern. I could keep going but it's going to take us a really long time to get to 35,000. So let's skip ahead a little bit here. What if I had five tons?

Carl: 10,000.

Mr. Kaye: Okay how did you get that Carl?

Carl: Because two times five is 10.

Mr. Kaye: Okay so what he is doing in his mind is he's thinking if one of these is 2,000 pounds, then I am going to take five and multiply it by 2,000. And what's that going to give me?

In this exchange, Mr. Kaye was guiding his students in filling out the table to find the answer to the question about the number of tons in 35,000 pounds. Mr. Kaye provided the approach, and the students provided the values for pounds. He asked for Carl's strategy, but when Carl provided an incomplete method, he did not probe further by asking for more information, much less ask him to justify his strategy. This resulted in the lowest level of *explaining mathematical thinking* and *source of mathematical ideas* because there was minimal teacher elicitation of student thinking and because Mr. Kaye was at the board with students responding to the math presented by the teacher without offering their own ideas. Mr. Kaye maintained tight control of the flow of the conversation and the students in general, indicating that the responsibility for learning remained with the teacher—the lowest level of the *responsibility for learning* indicator. In fact, at the end of the problem described above, one of the students stated that she got it right, but Mr. Kaye informed her that he did not think she confidently knew why she had gotten it right. The result was that all learning segments were rated at the lowest level for Math Talk Community. Perhaps the scores in Table 9 and Figure 1 mirrored the level of student thinking about mathematics because Mr. Kaye did all the thinking for the students; student input was designed to keep the students engaged and listening to the explanations rather than constructing their own mathematical concepts.

Table 9

Mr. Kaye's March 19, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
8:49	8:54	5		Student working on bell ringer— individual work	NA*	NA	NA	NA
8:54	8:57	3	5.56%	Bell-ringer review—whole group	2	2	2	2
8:57	8:59	2		Transition	NA	NA	NA	NA
8:59	9:25	26	48.15%	Group 1 on computer, Group 2 in guided practice	1	1	1	1
9:25	9:27	2		Transition	NA	NA	NA	NA
9:27	9:52	25	46.30%	Group 2 on computer, Group 1 in guided practice	1	1	1	1
9:52	9:54	2		Transition	NA	NA	NA	NA

*Not applicable

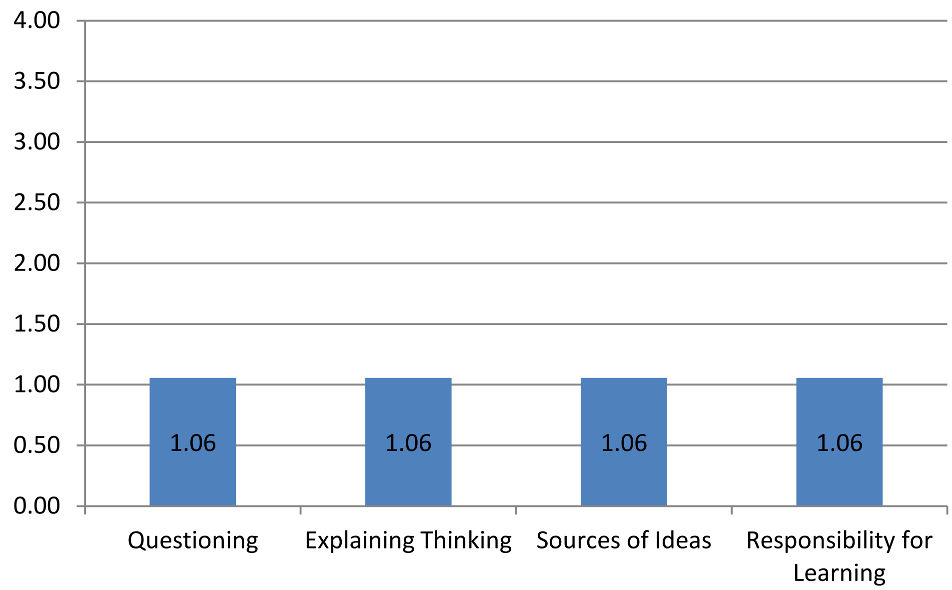

Figure 1. Mr. Kaye's March 19, 2015 Math Talk Community weighted scores.

Scoring the lessons with Marshall's (2013) discourse ecology factors seemed to be more precise and indicated some higher levels of discourse than the Math Talk Community categories were able to identify. For example, all levels of Math Talk Community were scored at the lowest levels for the guided practice segments, but the instructional and discourse factors (Tables 10 and 11) indicated higher levels of *instructional strategies* in these segments. It seems that the Marshall indicators were able to reveal the higher level of student engagement and the quality of the problems used, and Mr. Kaye's approach to guide students through the problems represented a demonstration to explain the process he wanted the students to use. This is scored a level higher than if he had simply lectured the students on how to solve the problems. His students were eager to respond to his questions, which was reflected in the higher *student role* scores.

The bell-ringer warm-up segment was scored at one level higher for *instructional strategies* than the guided practice because these were multiplication problems the students had not worked in a prior lesson. However, it was scored a level lower for the *knowledge acquisition* indicator than the guided practice segment because the students' learning was focused on rote process and not understanding. The guided practice was a review of problems students had already attempted earlier in the week. Because this was the second time the students had seen the problems and because of Mr. Kaye's control over the approach, *knowledge acquisition* was rated at a Level 2. This level indicates student learning was focused on mastery of process skills without much focus on understanding content.

Table 10

Mr. Kaye's March 19, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Students working on bell ringer—individual work	NA	NA	NA	NA	NA
Bell ringer review—whole group	2	2	1	2	1
Transition	NA	NA	NA	NA	NA
Group 1 on computer, Group 2 in guided practice	2	1	1	2	2
Transition	NA	NA	NA	NA	NA
Group 2 on computer, Group 1 in guided practice	2	1	1	2	2
Transition	NA	NA	NA	NA	NA

Table 11

Mr. Kaye's March 19, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Students working on bell ringer—individual work	NA	NA	NA	NA	NA
Bell-ringer review—whole group	1	2	3	1	2
Transition	NA	NA	NA	NA	NA
Group 1 on computer, Group 2 in guided practice	2	1	2	1	2
Transition	NA	NA	NA	NA	NA
Group 2 on computer, Group 1 in guided practice	2	1	2	1	2
Transition	NA	NA	NA	NA	NA

When considering Marshall's discourse factors, the bell-ringer review segment was generally scored higher than the guided practice segments. Based on the exchanged discourse above on decimal multiplication placement, Mr. Kaye focused learning on mastery of facts without much focus on understanding—*questioning* Level 1—but his questions were at the understanding level as he tried to ascertain how to place the decimals—*complexity of questions* Level 2. *Questioning ecology* was scored a Level 3 because Mr. Kaye was successful in briefly engaging student in open-ended questions of ”What if? and “How?”. *Communication pattern* was still at the lowest level, being closely controlled by Mr. Kaye, but the *classroom interactions* indicator was scored at

Level 2 because Mr. Kaye followed up a student's statement with a probe asking "What would happen?".

During the guided practice, Mr. Kaye's closed questions also rarely challenged students above the understanding level. Throughout the class, questions were at a higher level than simply recalling information, as demonstrated by the exchanges above when Mr. Kaye asked about unit conversion and had students help him fill in the tons/pounds table. This resulted in questions at Level 2. Questions in most exchanges were closed and focused one-word or short-phrase answers as in the examples above—the lowest level for *questioning complexity*. Mr. Kaye's entire process of going through both the bell-ringer warm-up and the three practice problems was orchestrated to engage students in oral questioning that filled in the blanks in his problem-solving, although he occasionally attempted an open-ended question, which demonstrated *questioning ecology* at Level 2. As mentioned previously, throughout the class Mr. Kaye was very much in charge of the communication, resulting in *communication pattern* scoring at the lowest level. However, *classroom interactions* were scored at Level 2 because of the occasional follow-up questions Mr. Kaye posed to students.

Observer reflections

Mr. Kaye had excellent classroom management skills; his students quickly and quietly performed the requested tasks with little confusion or questions. While the class was split between computers and whole-group discussion, he was constantly scanning students working on the computers, quickly redirecting as needed only a few times.

Many of the students participated in the whole-group review of the problems, and some were eager to answer his questions.

Feedback

At the end of class, I spoke with Mr. Kaye briefly in the hallway. He asked for feedback, and I shared my positive impressions of his classroom management and organization. I verified that this new schedule and students were new to him as of that Monday—four days earlier when the STAAR Blitz schedule began. I shared with him that his questioning was a bit closed and only required a single correct response by the students. I also shared my concern about the amount of support he provided while he worked through the problems and reduced the amount of planning and problem-solving students were required to do with that much support. I expressed my concern that the students may become too dependent on him and be ill-prepared to complete similar problems on the test without this level of support. I suggested that he consider a gradual release of support as he works the problems. Perhaps on the first problem, he should teach, ensuring correct procedures are used, but for the following problems ask students to take a bigger role in deciding how to solve the problems. He seemed to agree with my assessment of his questioning style, as well as my concern about students becoming too dependent on him for the problem-solving process.

During the PLC session that followed his class, Mr. Kaye spoke up and said that he tried my suggestion during the very next block. He taught the first problem in his usual way, but when he started the second problem he asked students to consider how they might solve it. He was pleased to hear the students' ideas and felt that it was a beneficial change.

Observation 2: March 25, 2015 / STAAR Blitz block B

General observations

Once again Mr. Kaye's classroom management was very efficient, and transitions were seamless. The students were respectful and quickly and quietly followed his very clear and calm directions. During the periods of time in which students were split into two groups, he was able to direct work in the whole group, as well as monitor student progress on the computers and answer questions asked by the students on computers. He modeled effective classroom management.

Student discourse observations

The class had five separate segments in which the discourse rubrics were not applicable: students entering class and gathering supplies, students grading other students' papers, and three transition periods. Mr. Kaye divided the class into two groups and conducted a facilitated a practice session with one group while he monitored the other group working on a mathematics computer program. These two sessions appeared to be almost identical in discussion and in the way Mr. Kaye facilitated the discussion. The last segment was a bonus opportunity that Mr. Kaye offered with the extra four minutes left in the block.

During the facilitated practice session, Mr. Kaye orchestrated a clear and concise problem exploration and solution. He began each of the three problems by asking a student to read the question. After the student read the question, he guided the students in understanding and solving the problems as a whole group as he had in the prior lesson. For example, this discussion was facilitated during the third problem:

Mr. Kaye: So in this situation they're giving you sets of ordered pairs. So in an ordered pair, which of these is x and which one is the y?

Student: The first is y.

Mr. Kaye: The first one is the x.

Student: The second one is the y.

Mr. Kaye: And then the second one is the y. Label that first ordered pair with x and y please. [Pauses while the students do as directed to label their points.]

Mr. Kaye: Okay, so what they're saying here is one of these ordered pairs does not follow the same rule as all the other ones in the table. So, let me give you an example with letter a. Let's just draw a line across your table because we are going to keep adding to it. So in this ordered pair, which one is the cost of the item?

Student: x.

Mr. Kaye: x. And so how much does the item cost?

Student: Ummm, x?

Mr. Kaye: How much would the item cost? $2.25 [Points to the $2.25 in the table on the board.] Okay? So Sherry, if I paid $2.25 for that, what are they telling me my total cost should be right here? [Points to $8.75

in the table on the board.] Sherry? What are they saying my cost should be?

Sherry: $8.75.

Note that the questions were closed and required only a single word or phrase, and Mr. Kaye did not follow up the students' responses with a "Why?" or "How?" question to explore student ideas. He asked all the questions and verified correct responses. He followed up incorrect responses by repeating his question, indicating the answer provided was incorrect, but did not attempt to elaborate or clarify students' misconceptions behind incorrect answers. It seemed as if by repeating his question, he felt that students either did not hear or did not understand the first time he asked.

However, in this lesson he occasionally had students talk at their tables to discuss possible answers to his question. This second distinct discourse pattern occurred five times in the two facilitated sessions when Mr. Kaye requested a strategy or explanation from students. At times students were directed to discuss at their tables, and other times students were asked directly and responded individually. He then returned to a very teacher-controlled, didactic pattern by working the problems with students responding to his questions about what to do next or what something was called. For example, when beginning the review of the first problem, Mr. Kaye directed students to talk at their table to discuss how to proceed with the problem solution:

Mr. Kaye: So when we went over these questions, the guided type questions on Monday, we said if we have a graph, what do we have to create on our own to check the graph again? What do we need to make on our own to check the graph again? Talk to the people at your table and look back at the guided questions we did again. What do we need to make? Flip back and look, flip back and look. What did we make, what did we make?

Students: [Look through notes with a few mumbles among them.]

Mr. Kaye: Alright Gen, what did we make?

Gen: A table.

Mr. Kaye: We made a table. So off to the side make a table. It can be off to the side or on scratch paper.

Students: [Fill in the table as directed by Mr. Kaye.]

This pattern of questions that explains what was occurring and asks students to fill in the blank is similar to the last observation, except that at times, Mr. Kaye also interspersed opportunities for students to discuss the answer at their tables prior to providing individual or choral responses. In subsequent table discussions, students spoke to each other more, but in general the prompt Mr. Kaye provided was a very basic prompt, like the example when he directed students to look over their notes from the past Monday and see what they should do next. He did not ask "Why?" or "How?", simply "What?".

The third pattern identified was one occasion when Mr. Kaye requested students consider an incorrect answer. For example, Mr. Kaye asked a student to tell him why he got an incorrect answer, and the student described the process he used to add the two numbers (9.50 and 6.50) while Mr. Kaye recorded it on the board. As the student was describing his algorithm for adding the two numbers, he discovered that he had forgotten to add \$1 from the sum of two \$0.50. While Mr. Kaye did not explore or elaborate on the misconception, the student was able to understand where the mistake had occurred in his calculation.

Using the Hufferd-Ackles et al. (2004) rubric to assess the levels of Math Talk Community in the facilitated practice sessions, *questioning* was scored at Level 1 because the majority of time was spent on the first pattern, where the teacher was the only questioner and students were requested to provide short, fill-in-the-blank type answers. However, *explaining mathematical thinking* was scored at Level 2 as Mr. Kaye requested students provide a strategy or explanation on five separate occasions. Similarly, *source of mathematical ideas* and *responsibility for learning* were scored Level 2 because Mr. Kaye generally dominated the discussions with his strategies and ideas about how to work the problems. There were five occasions in which he asked students for strategies or explanation, and the times he had students talk about the fill-in-the-blank question occurred in their table groups, showing evidence of beginning to set up a structure to facilitate students listening to and helping each other.

During the last segment, the questioning pattern was very different. Mr. Kaye began by verbally describing and writing on the board a table of values for variables x and y and requesting the students provide the equation corresponding to the table. As Mr. Kaye was describing the values, students excitedly began to raise their hands as they noticed the pattern. Once Mr. Kaye had finished describing the table and providing a few seconds of wait time, he asked students for the equation and a follow-up question about whether or not the relationship was additive ($y = x + a$) or multiplicative ($y = ax$). *Questioning level* and *explaining mathematical ideas* were low because the teacher was the only questioner and students only provided brief one-word or short phrases for answers with no follow-up explanations or justifications. However, *source of mathematical ideas* and *responsibility for learning* were squarely on the students. The teacher did not explain student thinking. Unfortunately, because of the pacing (perhaps because of the time constraint), he did not prompt students to explain their ideas or question each other. In this case, the Hufferd-Ackles et al. (2004) rubric falls short in accurately describing the shift in thinking (if not discussion) of the students. For this reason, I scored this segment as Level 2 for both; even though the students did not provide explanations, they were solely responsible for determining the solutions without the typical facilitation Mr. Kaye provided. The weighted results are displayed in Table 12 and Figure 2.

Table 12

Mr. Kaye's March 25, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
8:48	8:50	2		Students entering class and getting supplies	NA	NA	NA	NA
8:50	8:54	4		Students grading other students' papers	NA	NA	NA	NA
8:54	8:56	2		Transition	NA	NA	NA	NA
8:56	9:21	26	47.27%	Group 1 on computer, Group 2 in facilitated practice	1	2	2	2
9:21	9:22	1		Transition	NA	NA	NA	NA
9:22	9:47	25	45.45%	Group 2 on computer, Group 1 in facilitated practice	1	2	2	2
9:47	9:49	2		Transition	NA	NA	NA	NA
9:49	9:53	4	7.27%	Bonus opportunity: Students give the equation from a table	1	1	2	2

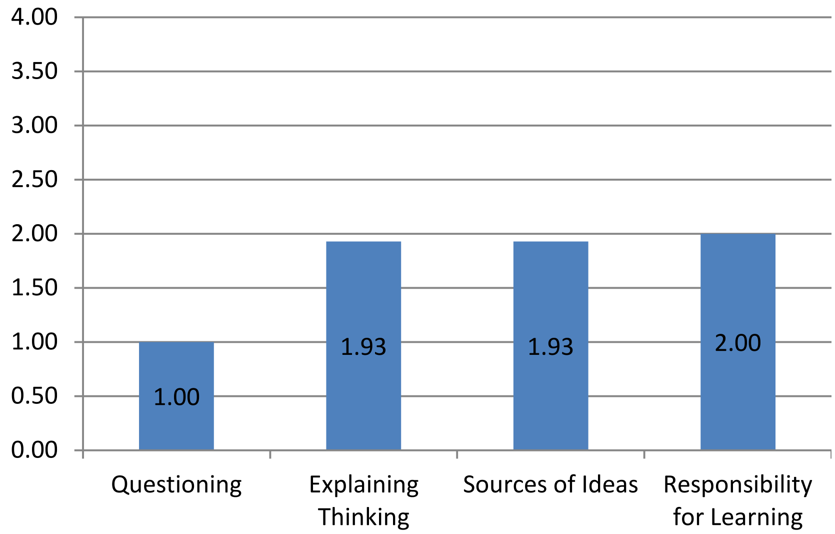

Figure 2. Mr. Kaye's March 25, 2015 Math Talk Community weighted scores.

An assessment of the discourse ecology of Mr. Kaye's actions was also made using the Marshall (2013) instructional factors and discourse factors. For the facilitated practice portion, Mr. Kaye demonstrated instructional and discourse factors at Level 2, as shown in Tables 13 and 14. *Instructional strategies* was rated at Level 2, as Mr. Kaye frequently lectured, but there were some discussions in which students participated. *Order of instruction* and *teacher role* were rated at Level 1, as the problems Mr. Kaye guided the students through were a review of prior material and not novel problems. Mr. Kaye's skillful management of the discussion meant that students were highly engaged for brief moments throughout, earning a Level 2 rating for *student role*. The *knowledge acquisition* indicator was rated at Level 2 as well because the lesson was focused on students mastering the process of matching tables and equations. When scoring the bonus opportunity segment, the ratings were much higher for instructional factors. It was scored at Level 4 for *instructional strategies*, as the students were fully engaged in the learning and Mr. Kaye simply provided the problem and verified the solution, Level 2 for *order of instruction* because students were asked to explore prior to explanation, and Level 4 for *teacher role* and *student role* because Mr. Kaye consistently acted as a facilitator and students were actively engaged as learners. *Knowledge acquisition* was rated at Level 2 because students were practicing a skill and not really applying the concept, explaining their thinking, or justifying their solutions.

Table 13

Mr. Kaye's March 25, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Students entering class and getting supplies	NA	NA	NA	NA	NA
Students grading other students' papers	NA	NA	NA	NA	NA
Transition	NA	NA	NA	NA	NA
Group 1 on computer, Group 2 in facilitated practice	2	1	2	2	2
Transition	NA	NA	NA	NA	NA
Group 2 on computer, Group 1 in facilitated practice	2	1	2	2	2
Transition	NA	NA	NA	NA	NA
Bonus opportunity: Students give the equation from a table	4	2	4	4	2

Table 14

Mr. Kaye's March 25, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Students entering class and getting supplies	NA	NA	NA	NA	NA
Students grading other students' papers	NA	NA	NA	NA	NA
Transition	NA	NA	NA	NA	NA
Group 1 on computer, Group 2 in facilitated practice	2	1	2	2	2
Transition	NA	NA	NA	NA	NA
Group 2 on computer, Group 1 in facilitated practice	2	1	2	2	2
Transition	NA	NA	NA	NA	NA
Bonus opportunity: Students give the equation from a table	3	3	4	1	1

Considering the Marshall (2013) discourse factors, the facilitated practice segments earned Level 2 on all indicators. Mr. Kaye's questioning remained as fill-in-the-blank style and asked students to state the next step in the process and not actually solve the whole problem. Mr. Kaye asked students for a strategy three times in each of the guided practice segments and added the talk-at-your-tables strategy, which increased the *communication pattern* score to a Level 2 from the previous lesson. The *questioning level* indicator changed to a Level 3 during the bonus opportunity segment, as students were challenged to apply their understanding of relationships to the tables Mr. Kaye provided. Students were challenged to reason through the relationship demonstrated by the table, but there was no explanation asked for or provided. It resulted in a Level 3 for the *complexity of questions* indicator. *Questioning ecology* jumped from a Level 2 during facilitated practice to the highest level during the bonus opportunity segment because the teacher provided the students a table and asked for the relationship in the form of an equation. Mr. Kaye consistently and effectively engaged his students in open-ended investigations. The communication pattern in both types of segments remained tightly controlled, little opportunity was provided in either for students to discuss in the facilitated practiced sessions (Level 2), and no opportunity was provided for discussion or explanation in the bonus opportunity (Level 1). The same was true for *classroom interactions*. There were a few opportunities in facilitated practice (Level 2), but none in the bonus opportunity (Level 1). This drop in the two last indicators may have been due to the lack of time remaining in the class period.

Observer reflections

Even though Mr. Kaye seemed very eager to follow my suggestions from the prior week and even shared with the PLC group how much he liked my suggestions and how he used it the very next class period, I was slightly surprised to observe him controlling the problem-solving and thinking in this lesson. He used a new discourse strategy of table talk, where he would ask a question and then have students discuss at their tables prior to answering. However, the prompts were low-level and students were encouraged to look at their notes and locate the answer. His exemplary classroom management and complete control of the classroom might have hindered him in allowing students to participate in classroom discussion and learning in any way other than what he had specified. An example of how his control might hinder students' responsibility for learning was when a student told Mr. Kaye that she had already completed a table. Mr. Kaye responded, "You are going to do it again; I want to make sure you've got it just the way I've got it." This same desire to control student thinking and work was also demonstrated when a student called out an answer:

Mr. Kaye: Put \$2.25 in the table and find out what should go in the y-column.

Sarah: \$8.75.

Mr. Kaye: I am going to need you to stop calling out the answer. \$2.25 plus \$6.50. I want you to add those together to find out what the y-value is supposed to be. [Pauses for students to add the two values.] Okay, raise your hand if you have found out what should go in the y-column. Yes, Corbin, what should go in the y-column?

Corbin: \$8.75.

In this exchange, while at least one student already knew how to get the correct answer, Mr. Kaye felt it necessary to slow down the whole-group discussion and tell the students how to determine the answer. Students had already explored the relationship, but he insisted on directing them to add and even told them exactly which values they should add. While this approach would seem very efficient and ensured that students followed his approach, it may not result in the student self-sufficiency required for rigorous standardized testing. While he provided an excellent modeling of his method to solve problems, I was not convinced that his students would be able to complete the work in future high-stakes tests without assistance similar to what was provided in class. Additionally, this very controlled discussion of solving problems was reflected in lower scores for discourse ecology indicators, like *responsibility for learning*, *knowledge acquisition*, *questioning* factors, and *communication pattern*.

Feedback

I provided Mr. Kaye the Math Talk rubric and the graphic from the last session. We spoke only briefly as he had a meeting during the math PLC. I pointed out that the rubrics only reflected the discourse I observed in his lesson and not the quality of his classroom management or other critical instructional components of a quality lesson. I asked him if he had considered using some of the student discourse strategies we had discussed that would allow his students more opportunity to explore problems before he explained solutions (which would increase his scores). I did not sense that he was as open to suggestions after this second observation. Perhaps when I provide feedback from this session, I should suggest strategies that will align with his need to control learning.

Observation 3: April 7, 2015 / STAAR Blitz block B

General observations

Mr. Kaye was absent for a prior observation, so this day became a make-up day. Consequently it fell on a different day of the week when the instruction was less a review of prior independent work and more a review of the concepts taught previously in the year, as well as some independent practice. The lesson began with a bell ringer (independent work while students got settled); Mr. Kaye used the whole-group review of the bell ringer to review the concepts being addressed in the independent practice that would follow. In the whole-group review, he asked students to read a problem individually and asked brief questions about what the problem was asking and what needed to be done. He then assigned different groups to work on the fraction-to-decimal division for different answer choices. The students worked silently and independently until Mr. Kaye asked individual students at various tables about each answer choice. Toward the end of the discussion, Mr. Kaye had the students take a brain break, in which they stood and stretched as directed. This questioning served as the concept review, and students were then directed to finish the rest of the practice independently. There were three students that quietly asked each other questions and helped each other out, but there were no other discussions observed.

Student discourse observations

The patterns of communication, while similar to previous observations, showed more solicitation of student ideas. Also, table groups were assigned different work to complete, and there were much longer periods of independent work. The discussion was didactic as in prior observations. There were still lengthy periods of explanation by Mr. Kaye and a few solicitations for explanation or strategies from students. One interesting exchange took place when a student was incorrect. Mr. Kaye asked another student to weigh in and then asked the first student if her ideas had changed his mind:

Mr. Kaye: Okay this right here, fastest to slowest. Be careful, be careful.

Students: [Indistinct]

Mr. Kaye: Okay I just heard two different things. Jennifer tell me what you just said.

Jennifer: I said least to greatest.

Mr. Kaye: Okay why?

Jennifer: Because you have the fastest, they want the least because that is the less time.

Mr. Kaye: Okay.

Jennifer: Because the slowest is whoever took the longest to run.

Mr. Kaye: It would be the slowest? Okay Sam, did she change your thinking?

Sam: [Nods.]

Mr. Kaye: Now Sam agrees.

Using the Hufferd-Ackles et al. (2004) Math Talk Community rubric, Mr. Kaye's lesson continued to score at the lowest *questioning* level because he was the only questioner. However, for the remaining categories the lesson was scored one level higher. Mr. Kaye asked a few questions requiring more extended responses and allowing for some probing of student thinking, like "How do we find it?", "What do we need to do?", or "What does absolute value mean?". This resulted in Level 2 scores for *explaining mathematical thinking* and *sources of mathematical ideas*. The higher scores were justified in *responsibility for learning* during the latter whole-group discussions because Mr. Kaye had table groups work out solutions to division problems and asked individual students at each table for their answers. It was not, however, in the bell-ringer review. Although Mr. Kaye asked the tables to work on the division, he did not encourage them to discuss their solutions prior to sharing with the whole group, and no student-to-student discourse was observed. Table 15 and Figure 3 display the Math Talk Community values—the long segment of independent practice was not considered for this analysis because students were expected to work independently and silently.

Table 15

Mr. Kaye's April 7, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
8:50	8:52	2		Students entering class and working on bell ringer	NA	NA	NA	NA
8:52	9:04	12	38.71%	Bell-ringer review	1	2	2	1
9:04	9:18	14	44.93%	Whole-group concept review	1	2	2	2
9:18	9:21	3		Brain break	NA	NA	NA	NA
9:21	9:25	4	12.90%	Whole-group concept review	1	2	2	2
9:25	9:27	2		Students beginning independent practice	NA	NA	NA	NA
9:27	9:29	2	6.45%	Additional directions and questioning	1	2	2	2
9:29	9:51	22		Independent practice	NA	NA	NA	NA

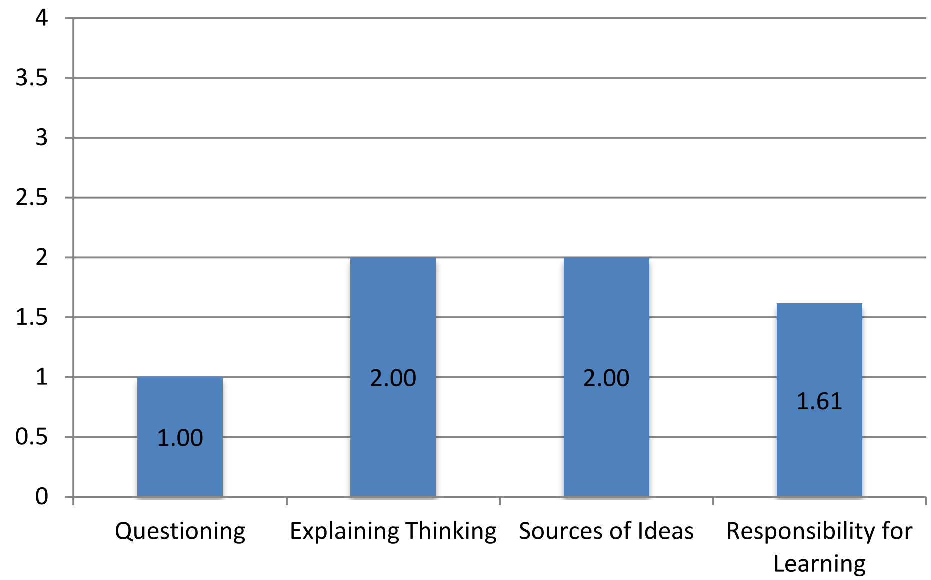

Figure 3. Mr. Kaye's April 7, 2015 Math Talk Community weighted scores.

Using the Marshall (2013) instructional factors rubric, the discussion segments were scored at Levels 2 and 3 (Table 16). Similar to prior lessons, Mr. Kaye did not lecture, but used didactic questioning to review concepts and demonstrated how to work problems on the board—*instructional strategy* Level 2. Also similar to earlier lessons, the concepts being presented were actually a review of material presented earlier in the year—*order of instruction* Level 2. As in the prior lesson, Mr. Kaye employed table-work or table-talk strategies in the lesson. While this did not always result in student-to-student discourse, it did demonstrate occasional facilitation—*teacher role* Level 2. Mr. Kaye continued to demonstrate a wonderful classroom culture in which most, if not all, students were engaged in learning, but only in response to Mr. Kaye's questions—*student role* Level 2. For this lesson, Mr. Kaye stated that they would be working the same types of problems as the day before. This indicated that while the concepts were not new, the problems or applications of the concepts were. This raised the *knowledge acquisition* level from 2 to 3. This Marshall indicator provided an opportunity to distinguish between the other three lessons observed. Because this was a Tuesday in the STAAR Blitz cycle, the problems used were novel compared to the problems used on Thursdays that reviewed Tuesday's problems. This increase did not necessarily mean a change in Mr. Kaye's instruction; it indicated a change in the type of day observed.

Table 16

Mr. Kaye's April 7, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Students entering class and working on bell ringer	NA	NA	NA	NA	NA
Bell-ringer review	2	2	2	2	3
Whole-group concept review	2	2	2	2	3
Brain break	NA	NA	NA	NA	NA
Whole-group concept review	2	2	2	2	3
Students beginning independent practice	NA	NA	NA	NA	NA
Additional directions and questioning	2	2	2	2	3
Independent practice	NA	NA	NA	NA	NA

Considering the Marshall (2013) discourse factors, all applicable segments received a Level 2 score (Table 17). *Questioning* was at the cognitive remember-to-understand (benchmark fractions) levels (“How do we convert fractions to decimals, division algorithm?”), but rarely was above these levels to application or analysis. Questions continued to be focused on quick one-word or short-phrase responses, but Mr. Kaye provided a few opportunities for students to respond to open-ended questions. Mr. Kaye again employed the table-talk strategy but it seemed less successful than in the prior lessons. Students focused on division computations during this time rather than discussions about mathematics.

Table 17

Mr. Kaye’s April 7, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Students entering class and working on bell ringer	NA	NA	NA	NA	NA
Bell-ringer review	2	2	2	2	2
Whole-group concept review	2	2	2	2	2
Brain break	NA	NA	NA	NA	NA
Whole-group concept review	2	2	2	2	2
Students beginning independent practice	NA	NA	NA	NA	NA
Additional directions and questioning	2	2	2	2	2
Independent practice	NA	NA	NA	NA	NA

Observer reflections

The discourse pattern was scored higher in some areas than in prior observations. While Mr. Kaye was definitely in control of the classroom, the answers students provided to his questions seemed to guide the review. At times he launched into an extended explanation, but these seemed to have resulted from student answers rather than a planned lecture. Overall, there seemed to be more student direction of the conversation. The increase in the Marshall (2013) *knowledge acquisition* score, as noted earlier, was due to the day of the week in the cycle of STAAR Blitz and not necessarily to a desire on Mr. Kaye's part to improve instruction. It is important to note here that some factors were influenced by the format and resources provided to teachers and not by something the teachers perceived they had the freedom to change.

Feedback

We discussed some common student misconceptions about place value when comparing and ordering real numbers in decimal form. I asked about the format of the lesson and verified that in this particular lesson students were required to independently explore problems. I also congratulated Mr. Kaye on his new position in the district. We spoke briefly about his position, and I suggested a few teachers he could contact to find out more about how they accomplished blended instruction in their mathematics classrooms. I did not mention student discourse in this feedback session as I felt like I needed to gain Mr. Kaye's trust and confidence in my ability to assist him.

Observation 4: April 16, 2015 / STAAR Blitz block B

General observations

Mr. Kaye had his students spend the first 25 minutes completing the independent practice as needed from earlier in the week. He also had an order–of-operations worksheet for students who completed the independent practice. The next 34 minutes (plus one minute for a brain break) were spent in whole-group review of the problems the students had just completed. Mr. Kaye used a variety of techniques during these two whole-group segments. The final segment of four minutes was a time in which students were directed to clean up and pack up prior to leaving the classroom.

Student discourse observations

During the whole-group discussion, Mr. Kaye employed his didactic practice of walking students through problems using closed questions that required short, single-answer responses. However, he also employed four additional strategies I had not observed in the three prior classes. He had a student go to the board and record answers from other students providing verbal responses to Mr. Kaye's questions. In this way, he began to facilitate students offering ideas about other students' mathematical ideas and solutions. He asked open-ended questions like, "How?" and asked students to add to the conversation by asking, "What else?". In the second segment, he also had students write their solutions on his teacher tablet for display on the board. Again, four different students worked four different order-of-operations problems simultaneously on the whiteboard at the front of the room. During this second segment, Mr. Kaye explicitly asked students to pay attention to their peers and be prepared to explain what they had done. The difference between the control Mr. Kaye exhibited in the first portion and the second portion of the class appeared to be a release of responsibility for doing the mathematics. He guided much more closely the first discussions and then allowed students to share their work and ideas about other students' work in the second session. These two segments were scored separately, and there was a significant difference in the scores for the second segment compared with the first, as well as with the lesson previously observed.

The student discourse ratings for the first whole-group review of the order-of-operations problems differed from the second segment. In the first whole-group segment, Mr. Kaye solicited student ideas about someone else's work, resulting in a Hufferd-Ackles et al. (2004) Math Talk Community score for *questioning* at Level 2. However, only on a couple occasions did he extend the conversation to ask a student about the thinking behind their answers—*explaining mathematical thinking* was scored at Level 1. Because Mr. Kaye engaged the students in recording work on the board and later in some error analysis and feedback of other students' work, *sources of mathematical ideas* and *responsibility for learning* were scored at Level 2. These scores represented at least one level higher in Math Talk Community scores of *questioning,* as he engaged students in a mathematical discussion of how to complete problems requiring order of operations. For the second segment, Mr. Kaye demonstrated an increase of one level for *questioning* because he was asking students to pay attention to other students' work:

Mr. Kaye: All right number four, I am going to hand somebody my iPad, and I need you to complete this factor tree, please.

Students: Ohh, ohh! [Excitedly raise their hands.]

Mr. Kaye: Josie, I need you to complete the factor tree. Check her work.

Josie: [Writes on the tablet.]

Mr. Kaye: George, why did she circle that?

George: ‘Cause uh, ‘cause uh...

Richard: That one’s wrong!

Mr. Kaye: What’s happened?

Richard: She has 15 times five.

Mr. Kaye: [Walks over to Josie and assists her quietly in fixing her factoring.] After she factors 15, I am going to have someone else come up and write the prime factorization.

He also was scored at Level 2 for *explaining mathematical thinking* and *sources of mathematical ideas* because he focused on procedural techniques and how the problems were worked by the students rather than on explaining “Why?”. The second segment was scored at Level 3 for *responsibility for learning* because students were responsible for writing on the board and Mr. Kaye encouraged students to “pay attention” to other students. (See Table 18 and Figure 4 for Math Talk Community scores.)

Table 18

Mr. Kaye's April 16, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
8:50	9:15	25		Completing independent practice from Tuesday	NA	NA	NA	NA
9:15	9:34	19	55.88%	Whole-group discussion on order-of-operations problems	2	1	2	2
9:34	9:35	1		Brain break	NA	NA	NA	NA
9:35	9:50	15	41.12%	Whole-group discussion on order-of-operations problems	3	2	2	3
9:50	9:54	4		Students reading silently and cleaning up	NA	NA	NA	NA

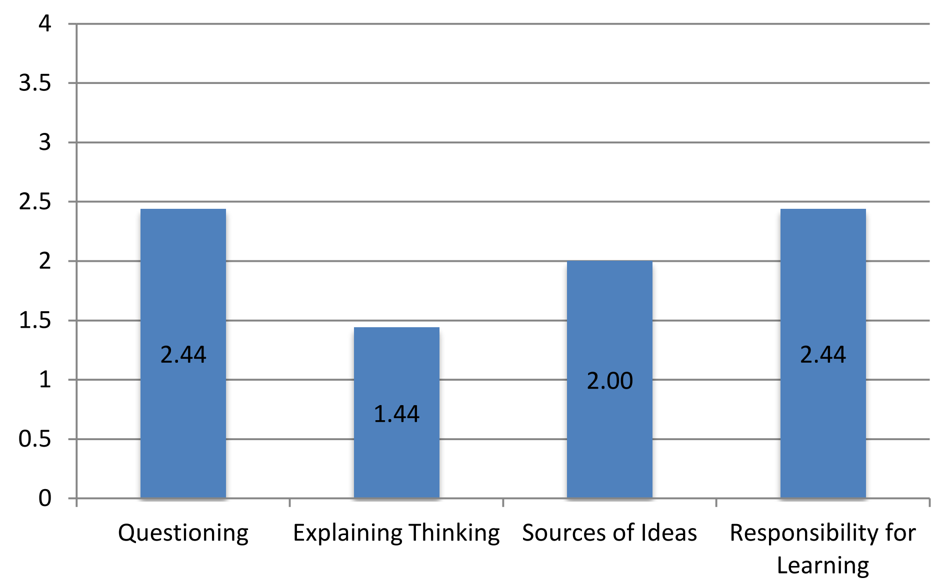

Figure 4. Mr. Kaye's April 16, 2015 Math Talk Community weighted scores.

For Marshall (2013) instructional factors, the lessons were scored at Level 2, Level 3, and Level 4 (the highest level). Level 2 was the rating for *instructional strategies* because activities were generally for verification purposes and not to explore the content. *Order of instruction* was also scored at Level 2. If this had been the introduction of the concept, perhaps this category would have been scored higher. *Teacher role* was scored at a Level 2 for the first segment and 3 for the second. While Mr. Kaye moved away from the board and allowed some students to record work on the board during the first segment, their writing was for the most part scripted by Mr. Kaye and did not include student-generated ideas. During the second segment, Mr. Kaye was not at the board and students were responsible for writing problems. It was tempting to score this second segment at Level 4 for *teacher role*, but Mr. Kaye still controlled the information—correcting students and telling them where and how to write rather than allowing the student to consider their work and make modifications or ask other students what should be done to change the approach:

Mr. Kaye: So she has eight plus 11 times two. Now the easy thing to do is to go and add these two first because it’s the first thing we see, but what does order of operations tell us to do first?

Students: Multiply.

Mr. Kaye: [To student writing on the board as he points at the board] So we multiply first, multiply. So we write it underneath it and bring it all down. Write 22 underneath it and rewrite the eight. Now the plus sign too. And then bring everything else down. I need you to do it this way. Always rewrite it every time. Here we go. Now that is 30 and we are all done.

While Mr. Kaye allowed the students to go to the board to present, he wanted to be sure that they wrote things on the board in order, as well as in the format he wanted.

Student role was scored at Level 3 for the first segment to reflect the increased student interest and participation in the discussion, including going to the board, and at Level 4 during the second segment because five separate students showed work, and all the students appeared to focus on what their peers were doing and whether or not they were correct. *Knowledge acquisition* was also scored at Level 2 for both segments, mainly because the questions and materials used by students were at a lower level of application, but also because Mr. Kaye's questioning elicited a "Why?" response, which he acknowledged but deflected the conversation to how to do order of operations:

Mr. Kaye: Okay, and why do I have that M and that D clustered together? [Points at the symbols for multiplication and division on the order-of-operations diagram.] Why are they next to each other Barbara?

Barbara: Because they are related, inverses.

Mr. Kaye: They are related; they are inverse operations. That's actually a very good vocabulary term there to use there. So what do we have to think about here? Do I always do multiplication first?

Students: No, yes.

Mr. Kaye: I heard "no" and I heard "yes." Be careful; there is a reason I have them grouped together. Do I always do multiplication first, Kasey?

Jerry: Oh I know.

Mr. Kaye: Mitch, what did you say?

Mitch: We do them left to right.

In this questioning, Mr. Kaye missed the opportunity to expand on the "Why?" answer Barbara provided and instead chose to focus on what came next procedurally. Mr. Kaye was very focused on students knowing "What?" and how to do the problems, but not why their strategies worked. This reduced the student discourse scores of his lessons and limited his students' discussions of mathematics to the lower cognitive levels of procedural understanding and not real mathematical proficiency required by the state's standards. (See instructional factor scores in Table 19.)

Table 19

Mr. Kaye's April 16, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Completing independent practice from Tuesday	NA	NA	NA	NA	NA
Whole-group discussion on order-of-operations problems	2	2	2	3	2
Brain break	NA	NA	NA	NA	NA
Whole-group discussion on order-of-operations problems	2	2	3	4	2
Students reading silently and cleaning up	NA	NA	NA	NA	NA

Marshall's (2013) discourse factors showed more variation but overall did not improve over prior lessons. In both whole-group discussions, Mr. Kaye asked procedural or “How?” questions to get at the process of employing order of operations, resulting in a *questioning* score of Level 2. Mr. Kaye did not ask for students to explain or justify their thinking, also resulting in a Level 2 for *complexity of questions*. While he employed new strategies such as the student going to the board, Mr. Kaye still controlled the discussion and really did not allow for exchange of the students’ ideas. In the second segment, he did inform students that they would have to explain the other students’ work, but this did not occur. Thus, *questioning ecology*, *communication pattern*, and *classroom interaction* remained at a Level 2 as well.

Table 20

Mr. Kay’s April 16, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Completing independent practice from Tuesday	NA	NA	NA	NA	NA
Whole-group discussion on order-of-operations problems	2	2	2	2	2
Brain break	NA	NA	NA	NA	NA
Whole-group discussion on order-of-operations problems	2	2	2	2	2
Students reading silently and cleaning up	NA	NA	NA	NA	NA

Observer reflections

Mr. Kaye demonstrated a much more flexible and student-centered exploration of the concepts in this lesson. The content seemed to be something that caused students a good bit of confusion. I remain curious if Mr. Kaye employed these techniques to engage students in discussion about these concepts because I was there or because of their confusion.

Feedback

I praised Mr. Kaye again on his ability to engage students in learning and his use of techniques. He stated that he was not sure about how he had several students go to the board at once because it was difficult to monitor and control that work, but he definitely saw the value in the approach. I assured him that what had occurred in his classroom was typical. We talked about discourse strategies he could use to choose student presentations that might make them more predictable. For example, he could have students attempt the work on paper first and he could circulate, observe, and choose students to share their work at the board. In this way, there might be fewer surprises. I also suggested he have students share their work using a document camera, which would save the time the students spent writing on the board.

Based on Mr. Kaye's response to feedback, I got the impression that he felt a bit out of his comfort zone when he could not control the discussion as carefully as he had in prior lessons. I was encouraged that he tried the technique and that he appeared to understand the utility in that approach. Mr. Kaye accepted a new position in the district during the course of study in which he will work to support a pilot of blended learning in the forthcoming year.

Summary of Student Discourse Observations Over Time

My first observation of Mr. Kaye's classroom occurred on March 19, 2015. While the campus mathematics coach and I had communicated by e-mail with the teachers, Mr. Kaye seemed surprised by my arrival, but welcomed me to his classroom. As seen in the detailed notes that follow, Mr. Kaye's approach to facilitating student discourse consisted of a controlled didactic pattern of closed questions requiring only single-word responses, which the students offered quickly and eagerly. The entire discussion was a model of efficiency as he detailed the correct approach to solving questions the students had struggled with on a prior independent assignment. He kept the students engaged by allowing them to provide answers to frequent, low-cognitive-level questions. Students appeared to follow his approach, and the expectation seemed to be that students should duplicate his approach when encountering a similar problem in the future. While students appeared to be engaged in the work because of their eagerness to respond to the low-level questions, it was difficult to assess the students' understanding of the concepts behind the questions or approaches to working out the solution because they were not asked to share this type of information. An example from March 19, 2015 follows:

Mr. Kaye: So what units are given in this problem?

Students: Quarts.

Mr. Kaye: And what units are in the answer choices?

Students: Cups.

Mr. Kaye: So what do we have to do to the quarts to make them cups?

Students: Convert them.

This type of didactic pattern with simple, short answers dominated the discussion. There were opportunities to ask students simple open-ended questions like "Why?" or "How?", but Mr. Kaye continued efficiently through the problems and how to solve them, sharing only his approach.

After this observation, I shared with Mr. Kaye my concern that his students might become too dependent on him when encountering mathematics questions because he so effectively guided them through every step of every problem. I suggested he consider gradually releasing control of some of the decision-making process to the students as they progressed through the problems to be discussed. The idea seemed to be novel to him, and he embraced it that day, using the suggestion in the very next Blitz block with his students and sharing it with teachers during the departmental meeting that followed.

Interestingly, when I returned for my second visit to his classroom on March 25, 2015, I saw a new strategy but noted only minor changes to his facilitation of whole-group discussion. During this session, the only observable difference was when he allowed students to talk within their table groups about possible answers to the closed questions prior to responding individually or together in a choral response. This small change was different than what we had discussed the prior week, but was still, in theory, an opportunity for students to engage in brief student-to-student discussions.

Unfortunately, Mr. Kaye's prompts for the table-group discussions were too low-level to generate rich student-to-student discussions.

Mr. Kaye indicated in his reflection on the lesson that his new strategy was to have students individually solve problems and then teach their solutions to their table groups. He indicated that he felt the strategy was "somewhat successful" (Mr. Kaye's March 25 lesson reflection, 2015). He also noted that students seemed more engaged during the discussion. He was also able to observe from conversations that his class needed work with vocabulary and how to model problems for others. This reflection aligned with my observations of his lesson.

Between the second and third observations, I received an e-mail from Mr. Kaye indicating that he would be out of the classroom at times because he had accepted a new position in the district for the following year. He would be assigned at the district level and would be responsible for leading a small group of mathematics teachers in a pilot of blended learning (a combination of face-to-face and online instruction). He was very excited about his new position and anticipated being absent from the classroom to begin conducting research and meetings for his new assignment. He was indeed absent the following week, but I was able to observe him on April 7 and April 16, 2015.

The third observation of Mr. Kaye's classroom fell on an independent practice day during the weekly STAAR Blitz cycle; perhaps this was the reason the discussion patterns were very different. While Mr. Kaye fell into his usual didactic pattern to review concepts at the beginning of class, he let the students share in some of the mathematics work for the remainder of their time. He assigned different novel computations to each table group and asked them to work together to determine a solution. After several minutes of the students working silently, Mr. Kaye asked for the answers to the division problems. Because the topic was order of operations, the problems and Mr. Kaye's questions focused on computational aspects rather than on mathematical concepts. In a discussion with Mr. Kaye following this class, he shared that he felt uncomfortable with the lack of control over what was happening and how long the discussion seemed to take. I made some suggestions as to how he could recognize and manage some of the less-productive periods, but also let him know that it seemed to be a much richer student discussion than prior classes.

The fourth and final observation was back on the typical review day in the weekly Blitz format. During the whole-group discussion, Mr. Kaye employed his didactic practice of walking students through problems using closed questions that required short, single-answer responses. However, he also employed student demonstration strategies I had not observed in the three prior classes. In fact, for much of the class period he was not at his usual location writing on the whiteboard. Instead, he allowed students to script his work or show their own work on the board. He appeared to be using some of the math talk moves described in Chapin et al. (2009) by having students restate other students' work and adding on to other students' responses. He also asked a few open-ended questions like "How?" and "What next?" to share responsibility with the students for solving problems. I briefly discussed my feedback with Mr. Kaye as we focused instead on his new project and position. He did express that he liked the new approach, but did not feel as proficient with it as with his didactic style.

Overall I was pleased to see Mr. Kaye trying new strategies and approaches in his classroom. He seemed resistant because he was very comfortable being in control of his classroom and of students' learning. However, by the end of our sessions together, he seemed to understand that the tight control of students and their learning (that had earned him accolades in performance appraisals) may not be in the best interest of students learning mathematics.

Mr. Kaye's weighted scores increased from the lowest levels in the first observation on March 19, 2015 to higher levels for all categories by the final observation on April 16, 2015, as seen in Table 21. The greatest growth was in the Math Talk Community categories of *questioning* and *responsibility for learning*. By the fourth lesson, Mr. Kaye progressed from being the only questioner and using short, frequent prompts keeping students engaged to asking more probing questions and expecting students to consider the work of other students. In the same way, he began to release to students the responsibility for learning by asking them to watch and perhaps explain other students' work.

Table 21

Mr. Kaye's Math Talk Community Scores Over Time

	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
03/19/15	1.06	1.06	1.06	1.06
03/25/15	1.00	2.00	2.00	1.59
04/07/15	1.00	2.00	2.00	1.61
04/16/15	2.44	1.44	2.00	2.44

While he did not achieve the highest levels of discourse described in the rubric, Mr. Kaye demonstrated attempts to begin to share the role of questioning and explaining with his students and started listening to his students' ideas about mathematics and approaches to problem-solving. A graph of these scores over time, in Figure 5, shows the increase visually.

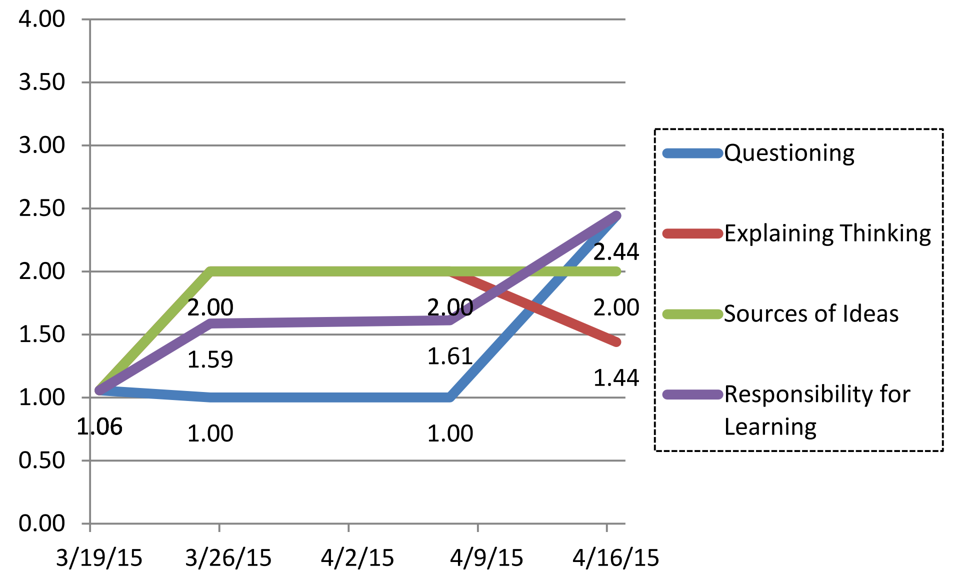

Figure 5. Mr. Kaye's Math Talk Community weighted scores over time.

Using the method described previously for the Math Talk Community scores, Mr. Kaye's lesson segments were also scored with Marshall's (2013) instructional and discourse indicators. Weighted scores were calculated for each lesson for all the discourse ecology indicators considered. Results comparable to Mr. Kaye's Math Talk

Community weighted scores can be seen using the Marshall (2013) instructional factors and discourse factors.

As mentioned previously, Marshall's (2013) instructional and discourse indicators appeared to clarify precise areas of change. The progress of Mr. Kaye's demonstration of the instructional indicators is displayed in Table 22 and Figure 6. Mr. Kaye demonstrated growth of one level in all the discourse ecology indicators except *instructional strategies*. While he did not demonstrate a traditional lecture approach of Level 1, he was focused on walking students through solutions to problems covering concepts they had, in theory, previously learned. He did not attempt to help students explore and develop conceptual understanding. These strategies placed his lessons at Level 2 throughout much of the intervention. Perhaps this was because he felt his job during the STAAR Blitz was to demonstrate how to do the problems correctly and not to help them understand mathematical concepts. The largest increase was seen in *student role*, which was scored close to Level 2 for the first three lessons only because Mr. Kaye had wonderful classroom management and frequently invited students to answer questions—albeit low-level questions. However, in the last lesson observed, Mr. Kaye had students showing and sharing their ideas for the solution on the board and considering other students' work.

Table 22

Mr. Kaye's Instructional Factors Over Time

	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
03/19/15	2.00	1.06	1.00	2.00	1.94
03/25/15	2.15	1.07	2.15	2.15	2.00
04/07/15	2.00	2.00	2.00	2.00	3.00
04/16/15	2.00	2.00	2.44	3.44	2.00

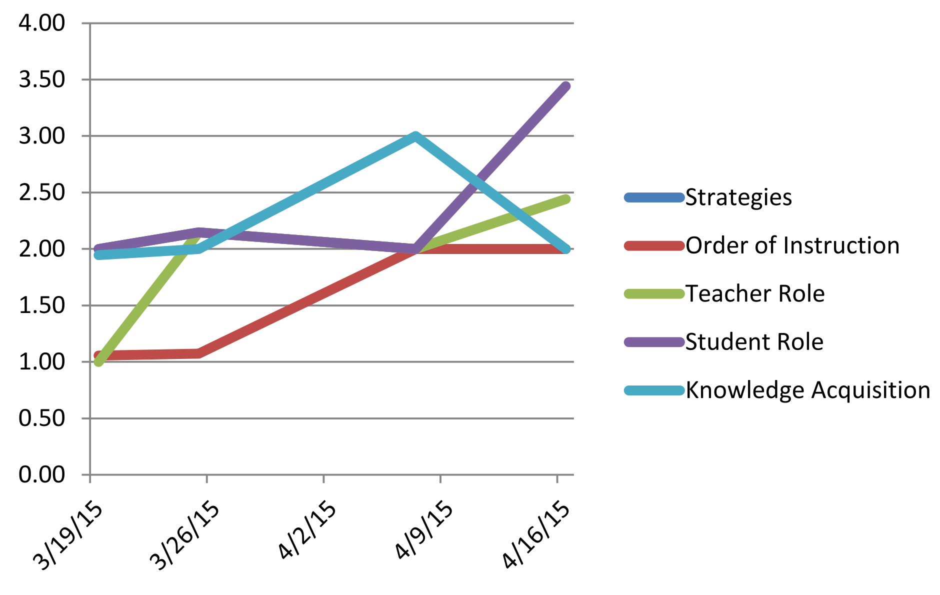

Figure 6. Mr. Kaye's instructional factor weighted scores over time.

Mr. Kaye showed little growth according to the Marshall (2013) discourse factors. He began with a *questioning level* at the remembering cognitive level (and at times the understanding cognitive level) and remained there for most of the intervention, as listed in Table 23 and illustrated in Figure 7. These data paralleled the *questioning* *ecology* and *classroom interactions* indicators, which all remained close to Level 2. While Mr. Kaye began at the lowest level of *complexity of questioning* and *communication pattern*, he did improve one level by providing some open response opportunities in later observations and by releasing to students some responsibility for representing solutions in the final lesson. For the most part he, or occasionally a student, followed up a student response with a basic probe focused on how to do a computation, but he was not able to employ more engaging probes that required students to explain or justify their reasoning.

Table 23

Mr. Kaye's Discourse Factors Over Time

	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
03/19/15	1.94	1.06	2.06	1.00	2.00
03/25/15	2.07	1.15	2.15	1.93	1.93
04/07/15	2.00	2.00	2.00	2.00	2.00
04/16/15	2.00	2.00	2.00	2.00	2.00

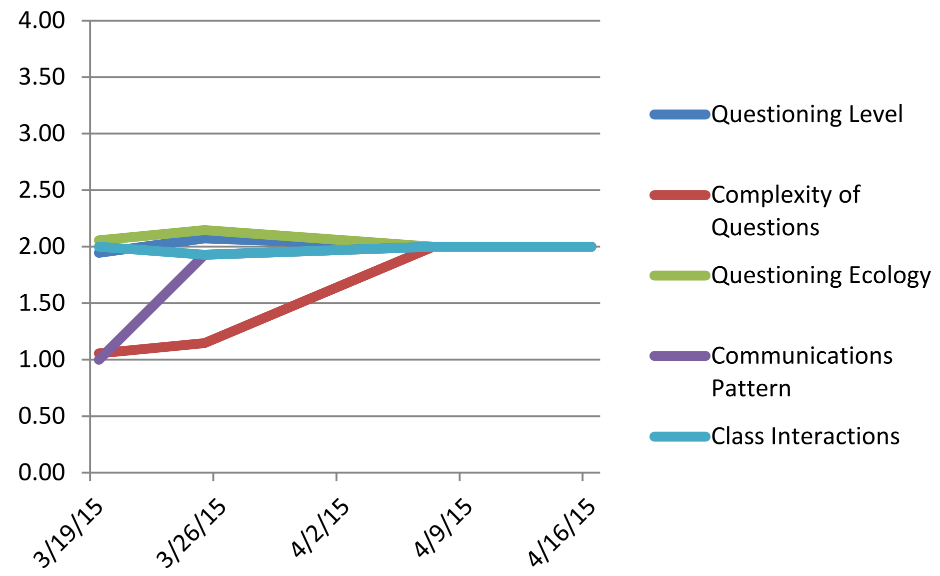

Figure 7. Mr. Kaye's discourse factor weighted scores over time.

Post-Intervention Perceptions and Beliefs

Mr. Kaye's responses in the post-coaching reflection survey evolved from phrases and one or two ideas in his initial reflection to full paragraphs with more description. For example, in his initial description of what it meant to know and do mathematics, Mr. Kaye stated "to understand why and how math 'works' and be able to apply it in new and novel situations." In his final reflection a few weeks later, Mr. Kaye responded:

> To know and do mathematics is to both understand mathematical principles and be able to apply them effectively when necessary. Knowledge of an algorithm is not "knowing and doing." Instead, knowledge of the concepts of math and how

they relate, then being able to use them in a variety of novel setting[s] show[s] understanding at a level far beyond that of a mere test-taker.

The increase in the response length and level of description indicates a richer understanding of the importance for developing conceptual understanding and application. It could also represent increased respect for me and the process of learning through coaching.

In addition to the changes in the length and descriptiveness in his reflection responses, he provided a much more robust definition of discourse. While his initial definition of discourse was a general statement about academic discussion with possibly some disagreement leading to consensus, his final description was specifically about the actions of students: how they talk, respond, and defend their mathematical reasoning. His final description even included students creating their own questions, strategies, and ideas, which, when shared, will lead to other students learning. This is an indicator that during the intervention Mr. Kaye considered and perhaps expanded his beliefs about discourse and its role in students' learning of mathematics.

The difference in Mr. Kaye's initial and final responses to the prompt about why he might want to increase his awareness of patterns of discourse in his classroom is also very interesting. His initial response mentioned the phrase, "the one who does the talking does the learning," as well as the need for his students to "talk more so they can hear from others and create their own understanding about math concepts." While he repeated the phrase above in his final response, he expanded his response to describe how students learn from talking:

> When students have a chance to talk and discuss, they more fully develop mathematics strategies and reasoning, especially when they have to defend their reasoning to others and explaining/justification will be required of them, they are more likely to work mindfully and strategically instead of just algorithmically.

With this richer description, Mr. Kaye seems to have evolved in his understanding of the phrase, "the one who does the talking does the learning," within the specific context of learning mathematics—and demonstrated an increased awareness of its importance to students learning mathematics.

Considering Mr. Kaye's enhanced descriptions of student discourse and possible reasons for increasing his awareness of these patterns in his classroom, it is understandable that his responses to prompts about his and his students' roles in the classroom seem to indicate frustration with the requirement to get students ready for the state test. For example, he indicated that while getting ready for STAAR he is primarily a lecturer—which is not his favorite role, but that was what he was required to do to fill in the gaps for his students prior to the test. He felt that he was much more of a facilitator when teaching math in the situation. He also described his students as primarily listeners and copiers of what he did in order to "get ready" for STAAR. He indicated that his preference would be for his students to be "willing explorers and risk-takers in the way that they try and solve problems." It is interesting that he felt the need to defend his and his students' roles as required for test preparation. It is possible that Mr. Kaye also felt the need to provide an excuse to himself or to me for the instructional strategies employed during my observations of the STAAR Blitz classes in light of a changed belief about the importance of student discourse. This frustration, as well as the increased length and details provided in the final reflection, signify a change in beliefs about student discourse and its role in students' learning of mathematics.

Conclusions About Changes in Beliefs and Instructional Practices

The goals of the intervention were to facilitate teachers' changing beliefs about student discourse and to increase teachers' capacity to facilitate effective strategies to improve student discourse in their mathematics classrooms—improved discourse ecology. In order to determine the success of the intervention, expressed teacher beliefs about discourse and its role in learning mathematics were compared over the intervention and in a post-intervention reflection. In addition, data gathered during the classroom observations were scored and compared over time using the Math Talk Community rubric (Hufferd-Ackles et al., 2004), as well as the instructional and discourse performance indicators from Marshall (2013) to ascertain observable changes in instruction related to student discourse.

The changes in Mr. Kaye's reflections from the beginning to the end of the coaching intervention suggest that Mr. Kaye spent some time reflecting on his beliefs about student discourse and its relationship to student learning. The longer and more detailed responses imply more clarity of understanding of student discourse and belief in the role of student discourse in learning mathematics. It is interesting to note that Mr. Kaye expressed his frustration with the constraints of the STAAR Blitz in his final reflection. It is as if his experiences and reflection during the coaching intervention called attention to the disparity between his instruction in the STAAR Blitz and the type of instruction he felt was ideal for students to learn mathematics.

In spite of the constraints of the STAAR Blitz, Mr. Kaye attempted new strategies to begin implementing somewhat higher levels of student discourse within the format and questions provided for the STAAR Blitz. From the first observation through the fourth observation, Mr. Kaye's lessons exhibited an increase in discourse ecology. For most indicators of discourse ecology (Hufferd-Ackles et al., 2004; Marshall, 2013), Mr. Kaye achieved an increase of one or two levels, with the exception of *questioning level*, *questioning ecology,* and *classroom interactions*. Given additional time or perhaps a regular class format (rather than the STAAR Blitz), Mr. Kaye may have been able to reach the higher levels of these discourse ecology indicators.

Given Mr. Kaye's confidence in his teaching ability and his polished skills in modeling problem-solving using a didactic questioning pattern at the beginning of the intervention, I was not certain he would be willing to attempt new strategies or even that he would value the importance of student discourse in learning. However, he thoughtfully considered the types of strategies he might use in upcoming lessons and reflected on their relative success. I do not believe he would have made this effort had it not been for the intervention. He seemed content to use his tried and true didactic approach, and it was only with some prompting that he began to reflect on its lack of effectiveness to improve students' understanding of mathematical concepts.

It was very rewarding to work with Mr. Kaye. While the growth he experienced may have been possible without the intervention, I do not think that he would have made the effort to improve his discourse ecology. It appeared that he was experiencing the plateau that occurs with some successful, experienced teachers. Mr. Kaye might not have reflected on the status of student discourse in his classroom and tried to implement new discourse strategies if it had not been for the intervention.

The Case of Ms. Anderson

Background

Ms. Anderson had 12 years teaching experience at the time of the intervention, but it was her first year at Southeast STEM Center. She was actually hired to be the campus mathematics interventionist, but was placed in the classroom mid-year when another teacher was reassigned. Prior to her work at this sixth-grade campus, she had worked at the elementary level (which in Texas is generally kindergarten through fifth grade). Ms. Anderson shared this information with me early in the intervention, along with her uneasiness with large groups of sixth-grade students.

Ms. Anderson is a White female in her early 30s. The intervention class I observed was sixth period containing 25 students—15 African-American boys, seven African-American girls, two Latina girls, and one Latino boy. (In subsequent observations, the number of students varied from 24 to 27.) There was an aide assigned to her classroom during that class period in order to provide inclusion support for one or more students receiving special education. The classroom was small and very crowded once the desks were filled. During one lesson, a new student arrived after the class had started, and Ms. Anderson never noticed. The class aide welcomed the student, checked his schedule, and found out he had arrived during the wrong class period.

Pre-Intervention Perceptions and Beliefs

Ms. Anderson responded to the pre-intervention questions provided. She recalled attending approximately three hours of professional development on student discourse prior to the intervention. She also stated that she did not recall the key ideas from the prior training.

Individual Lesson Observations, Discussion, and Scoring

Observation 1: March 19, 2015 / sixth period

General observations

I arrived a few minutes into the class period and thus only observed the whole-group discussion portion of the lesson. When I arrived, Ms. Anderson was at the board walking students through geometry application problems. It was a full classroom with a special education aide circulating and assisting students as Ms. Anderson directed the discussion. The students seemed generally restless during the whole-group discussions, and Ms. Anderson had to redirect students a few times. Ms. Anderson directly worked the first problems with minimal student input. On the last problem, Ms. Anderson allowed students to talk with partners briefly.

Student discourse observations

During the whole-group discussion of the geometry problems, Ms. Anderson guided students through solving the problems on the board. She asked students what shapes they saw in the problem and which formulas might apply. She helped students identify dimensions of shapes so that they could determine which answer choice matched the situation presented:

Bob: [Reads number 4.]

Ms. Anderson: Okay. So he used two figures. We already found the bottom figure, didn't we? Didn't we already find area down here?

Students: Yeah.

Ms. Anderson: So we said this one was five plus 3.5 times what?

Students: Eight.

Ms. Anderson: Times Eight. So now, what's our other figure at the top?

Students: A triangle.

Ms. Anderson: Who remembers the formula for the area of a triangle?

Student: Isn't it uh…

Ms. Anderson: Jackie, thanks for raising your hand. What is the formula for the area of a triangle?

Jackie: Base times height divided by two.

Ms. Anderson: Exactly. One-half base times height or base times height divided by two.

While her questioning was didactic, she appeared to be looking for student ideas more than just quick answers to her questions. She asked questions that attempted to support student thinking about geometric concepts, with some probing questions aimed at understanding students' level of knowledge and misconceptions. She asked why a shape was classified as a rectangle instead of a square. She asked a student to help out another student struggling with a response. She also asked students to justify a response:

Ms. Anderson:	I hear someone who got it. Listen. Listen. Jackie what did you find out?
Jackie:	It's four.
Ms. Anderson:	How do you know it's four?
Jackie:	Because, because, because, it's um...I just think it's four.
Ms. Anderson:	It tells us somewhere. Tyler, do you know?
Tyler:	Because it's a fraction.
Ms. Anderson:	It tells us it's a four-by-six card. So, that means this side would be how long? [Points to the shape on the board.]
Students:	Four.
Ms. Anderson:	And the other side would be?
Students:	Six.
Ms. Anderson:	So now we know our height. Don't we?

While she may not have always been successful in engaging the students in explaining or justifying, she did ask questions attempting to uncover student thinking about their mathematical ideas and reasoning.

Toward the end of class when she asked students to think about what the question was asking and which formula should be used, she did not answer the question, but had students turn and talk to their neighbors about volume and what they knew about it. At this point in the lesson, the Math Talk Community levels of *explaining mathematical thinking*, *sources of mathematical ideas*, and *responsibility for learning* increased. Because of the occasions in which Ms. Anderson asked “Why?”, “Who can help her out?”, and “How do we know?”, the Hufferd-Ackles et al. (2004) Math Talk Community indicators for *questioning*, *explaining mathematical thinking*, and *sources of mathematical ideas* were all scored at a Level 2. These probes demonstrated her desire to begin focusing on student thinking and strategies, although she remained the main source for ideas. At the end of the lesson when she had students turn and talk, she began to set up structures for students to listen to each other’s ideas about mathematics, which resulted in a Level 2 for *responsibility for learning*. (See Table 24 and Figure 8 for Math Talk Community scores.)

Table 24

Ms. Anderson’s March 19, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
12:57	1:15	18	100%	Whole-group discussion	2	2	2	2
1:15	1:16	1		Students packing up and exiting classroom	NA	NA	NA	NA

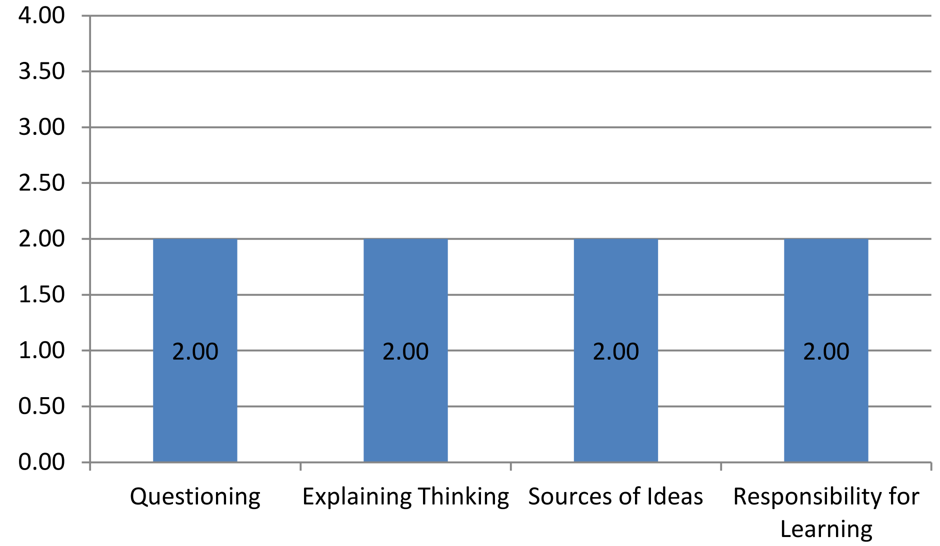

Figure 8. Ms. Anderson's March 19, 2015 Math Talk Community weighted scores.

When scoring the Marshall (2013) instructional factors (Table 25), we notice the efforts of Ms. Anderson to raise the students' level of thinking about mathematics, but we can also see that she was generally unsuccessful. The *instructional strategies* and *order of instruction* indicators were scored at Level 2, as she asked questions to guide students' exploration of the concepts. The problems she chose were difficult and required students to apply their knowledge of area and shapes to find the areas of composite figures. Ms. Anderson maintained learning at the application level without oversimplifying concepts for her students. However, *teacher role* and *student role* indicators were scored at Level 1, as Ms. Anderson attempted to manage her class and guide the discussion, but was only successful in engaging some of the students consistently throughout the lesson.

Table 25

Ms. Anderson's March 19, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Whole-group discussion	2	2–3	1	1	3
Students packing up and exiting classroom	NA	NA	NA	NA	NA

Similarly, most of the Marshall (2013) discourse factors (Table 26) indicated that Ms. Anderson began to challenge students to explain their thinking and apply their understanding of geometric concepts, but struggled in these efforts:

Ms. Anderson: Is that the height? [Points to a value on the figure.]

Student: Yes.

Ms. Anderson: How do you know it is four?

Student: Because it is going [motions hand up and down vertically].

While Ms. Anderson asked questions that challenged student understanding, and at times application and analysis levels (Levels 2 and 3 of the *questioning level* indicator), these attempts were unsuccessful. She also asked "explain" and "justify" questions with "Why?" and "How do you know?", which is Level 3 for *complexity of questions*. However, she was rarely successful in engaging students in discussions, earning a Level 2 for *questioning ecology*, *communication pattern*, and *classroom interactions*.

Table 26

Ms. Anderson's March 19, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Whole-group discussion	2–3	3	2	2-3	2
Students packing up and exiting classroom	NA	NA	NA	NA	NA

Observer reflections

I was concerned about the general restlessness of the students and how crowded it seemed in the classroom. One reason for the restlessness could have been because this class was immediately after lunch. Ms. Anderson appeared to struggle with control of the students. Her inability to manage the classroom and a culture that seemed to lack respect for the teacher and fellow students appeared to make a big impact on her ability to engage the students in rich mathematical discussions. She shared some of the questioning strategies she had tried previously, but felt she was not successful because of the students' behavior.

Feedback

Ms. Anderson shared with me that she had not really taught geometric concepts previously in the year, but had only shared that content during bell ringers. This is the first time she was teaching the students geometry concepts, and she seemed concerned about how it was going. In an e-mail, I suggested she consider using some of the math talk moves from the professional development. I hoped it would help her structure her discussions by using strategies like “revoicing” and “adding on” to engage all the students in discussions. I also suggested some other strategies to help with her classroom management skills and general restlessness of the students, like seating charts. I also suggested using more small-group activities that would allow the students more opportunities to share their mathematical ideas verbally.

Observation 2: March 25, 2015/ sixth period

General observations

Ms. Anderson divided the students into groups based on the results of an assessment from earlier in the week. While the setup of small groups took some time, the discussion in the groups appeared to be valuable and more effective than the whole-group discussion observed previously. She assigned five warm-up problems written on the board as she circulated and prompted student thinking and learning within the groups. At the end of the individual work on the warm-up, there was whole-group discussion about the problems. A small-group discussion followed the discussion of the warm-up problems, in which student groups were each assigned a different problem and asked to present their solution to the whole group.

Student discourse observations

Students first worked five warm-up problems, followed by a whole-group discussion. During the discussion, the teacher appeared to begin with higher-level or open-ended questions, but when students struggled to respond, she quickly asked questions to scaffold thinking from a lower level for integer operations. Ms. Anderson also employed a strategy of asking students for their solution, but without verification continued to ask for additional solutions. For example, students answered with both positive and negative responses. Ms. Anderson asked, “Who else got positive one?”. Students raised their hands. “Who else got negative one?” Other students raised their hands. Ms. Anderson then referred students to the rules they had learned for adding integers. In a didactic pattern, she helped them recall the rules and apply them to the problem to decide for themselves which answer was correct.

Following the warm-up review, Ms. Anderson launched into a review of the concept of independent and dependent variables and a graphic they had learned to help them remember which was which. During this discussion, Ms. Anderson guided the students through recalling prior learning about the variables, ordered pairs, and some characteristics of additive and multiplicative relationships.

During the small-group discussion, the students were occasionally off task, but seemed more concerned with having a good response prepared when it came to presentation time than they did with the individual bell-ringer assignment. In the two discussions observed, students were making statements about which answer they thought was correct and why. Fellow students in the group would then make their assertions and back their claim with some evidence.

During the student presentations, the first group needed support in sharing their response and the reasoning behind it. Ms. Anderson returned to the scaffolding pattern from earlier, asking the group to tell the class what they had done. Once the students stated the correct answer, Ms. Anderson asked them “Why?”. When the student struggled in his response, Ms. Anderson instructed the group, “Y’all help him” and asked, “Can you explain it?”. The second group was more successful in their explanation. They took turns and provided justification for their answer choice:

Ms. Anderson: So we are looking for a statement that’s what?

Student 1: True. Table 1 is multiplicative because it’s times three and Table 2 is adding by four.

Ms. Anderson: Good, okay.

Student 2: A isn’t the answer because adding in Table 1 and multiplying in Table 2.

Ms. Anderson: So A is what? True or false?

Students: False.

Ms. Anderson: Okay.

Using the Hufferd-Ackles et al. (2004) rubric to assess the levels of Math Talk Community, Ms. Anderson’s *instructional strategies* had changed compared with the first observation. During the whole-group bell-ringer review, the scores were at the second level for all indicators—*questioning, explaining mathematical thinking, sources of mathematical ideas*, and *responsibility for learning*. These scores reflected Ms. Anderson’s questions asking for alternative solutions and the reasoning behind student answers. She also attempted to engage students in thinking about other students’ responses—beginning to share the responsibility for learning with them. The scores also reflected the limited success she had in engaging students in such reasoning as she took the opportunity to revisit the rules for integer operations they had learned previously. Once the review of the warm-up problems was completed, Ms. Anderson provided a brief review of independent and dependent variables. This review was much more teacher-focused, with low levels of *questioning*. This segment, while interactive, was scored at the lowest level for Math Talk Community.

She obtained much greater success engaging students in a Math Talk Community during small-group discussions. This segment was scored at the highest levels of Math Talk Community, as it exemplified the shift to "students acting in central or leading roles" (Hufferd-Ackles et al., 2004, p. 88). While Ms. Anderson may not have been successful in engaging all groups, those observed demonstrated these characteristics. In the following exchange, students were given a table of values and attempted to determine which variable was independent and which was dependent:

Student 1: Independent is y.

Student 2: Independent is x so I think it is G.

Student 1: G not H? 'Cause two and four.

Student 2: You know why I think it's G. 'Cause you know how I think it's G? 'Cause you know how they double it? That's why I think it is G instead of H.

Student 1: Yeah, yeah.

Following these small-group discussions, two groups had the opportunity to present their results and reasoning at the board in front of the rest of the class. This strategy allowed students to listen to their peers, and Ms. Anderson probed for reasoning behind the student ideas if they did not volunteer it. However, during this exchange, while the rest of the class was listening, no one interjected with questions or ideas of their own. By verbalizing her expectations that students state their solutions and explain “Why?”, Ms. Anderson was able to raise the level of *explaining mathematical thinking* to Level 3. However, Ms. Anderson was not successful in actively engaging the rest of the class, which resulted in all other factors scoring at Level 2. The scores for Math Talk Community are shown for each segment in Table 27. The weighted scores for the entire lesson in each category are displayed in Figure 9.

Table 27

Ms. Anderson’s March 25, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
12:36	12:41	5		Students entering the classroom and finding seats	NA	NA	NA	NA
12:41	12:44	3		Student working on warm-up—individual work	NA	NA	NA	NA
12:44	12:49	5	16.13%	Whole-group review of warm-up	2	2	2	2
12:49	12:58	9	29.03%	Whole-group review of integer operations	1	1	1	1
12:58	12:59	1		Directions—transition	NA	NA	NA	NA
12:59	1:05	6	19.35%	Small group—student-to-student discussions	4	4	4	4
1:05	1:06	1		Directions—transition	NA	NA	NA	NA
1:06	1:17	11	35.48%	Student groups presenting to class	2	3	2	2
1:17	1:18	1		Students packing up and exiting classroom	NA	NA	NA	NA

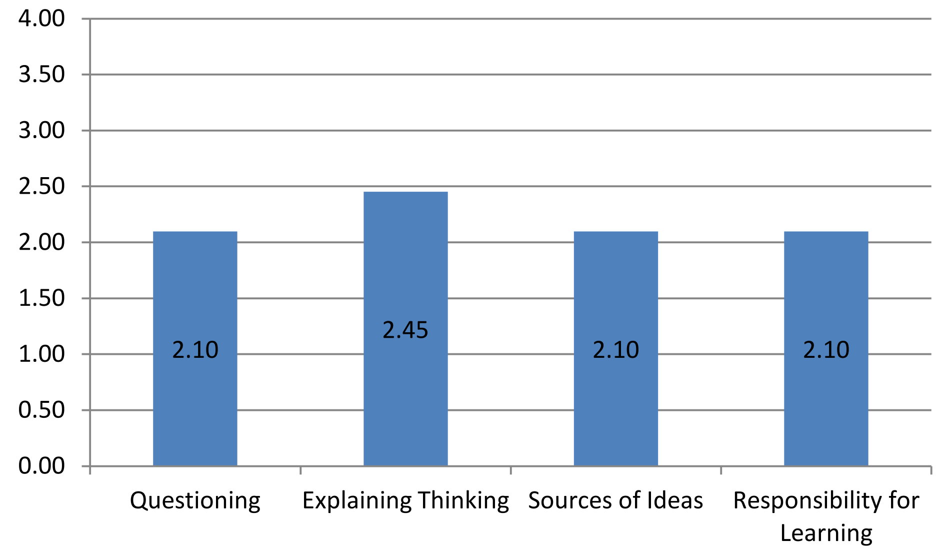

Figure 9. Ms. Anderson's March 25, 2015 Math Talk Community weighted scores.

Using the Marshall (2013) rubric to score the instructional factors, the similarities between the whole-group review of the bell ringer and the whole-group review of the independent and dependent variable concepts were revealed in identical scores—though at times for slightly different reasons. In considering *instructional strategies* and *order of instruction*, Ms. Anderson ended up lecturing and using demonstrations to explain content (Level 2) and asked students to explore the warm-up or reviewed previously explored content, which was scored Level 2. For *teacher role* and *student role*, both whole-group discussions turned into the teacher becoming the center of the discussion as she was forced to ask more and more questions attempting to get to the solutions and explanations, resulting in Level 2 for each. The topic of the warm-up was basic integer operations (Level 2 for *knowledge acquisition*), and the topic of the review was focused on recall of concepts rather than development of concepts (Level 2).

In contrast, the small-group discussions scored much higher than the whole-group reviews and somewhat higher than the student-group presentations (mainly due to students being passive during the presentations and the additional scaffolding some groups required). Both the small-group discussion and the student presentations allowed students to investigate and share ideas (Level 3 for *instructional strategies*), plus students were exploring problems that required application and analysis of their understanding of independent and dependent variables (Level 3 for *knowledge acquisition*). During the small-group discussions, the teacher was a facilitator and the students were active learners (Level 4 for *teacher role* and *student role*), but during the student-group presentations, Ms. Anderson returned to prompting more for more student ideas (Level 3 for *teacher role*). The students not presenting tended to be more passive (Level 3 for *student role*), and while Ms. Anderson set up the expectation for full participation in the small groups, she was not consistently successful at engaging all the students in on-topic discussions. A summary of these scores is displayed in Table 28.

Table 28

Ms. Anderson's March 25, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Whole-group review of warm-up	2	2	2	2	2
Whole-group review of integer operations	2	2	2	2	2
Small group—student-to-student discussions	3	4	4	3	3
Student groups presenting to class	3	3	3	3	3

Similar scoring occurred in Marshall's (2013) discourse factors. Most discourse factors for the two whole-group discussions were Level 3, as the teacher attempted to probe and encourage students to present reasoning and justification. However, in the small-group discussions, the students were forced to listen and explain their reasoning to other students in order to prepare for their presentations. This resulted in Level 3 scores on all discourse factors, except a Level 4 score on *communication pattern*. Scores on the student-group presentations for most indicators were at Level 3 because students were responsible for the discussion, but were guided at times by Ms. Anderson. The exception was the *student role* indicator, as Ms. Anderson struggled to engage more of her students in the discussion. The scores are summarized in Table 29.

Table 29

Ms. Anderson's March 25, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Whole-group review of warm-up	2	3	2	2	2
Whole-group review of integer operations	2	2	2	2	2
Small group—student-to-student discussions	3	3	3	4	3
Student groups presenting to class	3	3	3	2	3

Observer reflections

While the whole-group discussion segments seemed to result in very similar scores to the prior week, the small-group discussion and student-group presentations made a significant difference. Students appeared to feel a greater sense of urgency and responsibility for learning. These strategies employed by Ms. Anderson raised the Math Talk Community of the lesson and improved the discourse ecology overall.

Feedback

Ms. Anderson shared that her job at the beginning of the year was campus interventionist, and her experience before this year was as an elementary teacher and interventionist at that level. She expressed frustration at being thrust into the role of classroom teacher and expressed her preference for working with small groups. She also shared that she is currently working on a master's degree in educational technology and library science. This reinforced my belief that she may not feel comfortable teaching a classroom of 20 to 30 mathematics students several times a day. I reiterated some classroom management techniques, like seating charts, and suggested she review student norms. She expressed that she felt the students did not agree or feel the need to follow the class rules posted. I suggested that perhaps she could have the students create their own set of norms to give them voice and to help with gaining student support for the norms. I probed to find out more about her preferred teaching method, and we talked about how she could use some of her questioning techniques to increase student engagement and hopefully reduce student disruptions.

Observation 3: April 2, 2015 / sixth period

General observations

Ms. Anderson spent a large portion of the 45-minute class time getting students in and settled; this was troubling. However, with the campus discipline issues, perhaps spending time to maintain classroom discipline could not be avoided. The students were arranged in groups of four for the entire class, and the lesson was a combination of small-group explorations and whole-group debrief sessions about the problems. Ms. Anderson began the mathematics portion of class by having students consider some one-step equations as part of the bell-ringer warm-up. After observing the students struggling to solve the equation, she wrote new problems on the board one at a time. She had students attempt to solve the equations with a partner, and then she conducted a whole-group discussion where some students shared their solutions—at times showing their work on the board.

Student discourse observations

During the whole-group debrief discussions, there were four distinct patterns noted: didactic walk-through of the problem steps; a brief turn-and-talk, in which students discussed the questions and checked their answers; the teacher asking students for explanations and reasoning; and on one occasion a student asking questions seeking clarification. The Hufferd-Ackles et al. (2004) Math Talk Community was scored at Level 3 for *questioning*, and the remaining categories (*explaining mathematical thinking, sources of mathematical ideas*, and *responsibility for learning*) were scored similarly to previous sessions at Level 2. The higher *questioning* level was the result of students sharing their ideas about how to solve the equations:

Ms. Anderson: Anybody get nine?

Student: I got nine.

Ms. Anderson: Did anybody get a negative number for their answer?

Students: No.

Ms. Anderson: Anybody get less than nine?

Student: I got 40!

Ms. Anderson: 40? How did you get 40? Tell me Tara.

Tara: You got to put a six up there [points to one side of the equation].

Ms. Anderson: What kind of six?

Tara: A positive.

Ms. Anderson: So I add six to negative six.

Tara: And it's going to be zero and six over there is 40.

Ms. Anderson: So I'm adding six to both sides.

Tara: And you get 40.

Ms. Anderson: 40 because adding a negative is really subtracting a number. Because adding six is the same as subtracting negative six.

The other categories were scored lower because students struggled to explain their approach, and the teacher ended up filling in the explanation herself, stating, "We need to get through this." The small-group discussions, in which students explored how to solve a problem prior to whole-group review of the solution and strategy, were scored a level higher for *questioning*, *explaining mathematical thinking*, and *sources of mathematical ideas* because students were holding each other responsible for sharing mathematical ideas and reasoning. They were not scored at the highest level because some students were not on task and the student levels of discussion seemed to indicate that they did not have enough prior knowledge to participate in an adequate conversation about problem solutions. This was a very deliberate attempt by Ms. Anderson to engage the students in a richer discussion focused on strategies to facilitate conceptual understanding. (See Table 30 and Figure 10 for Math Talk Community Scores.)

Table 30

Ms. Anderson's April 2, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
12:35	12:39	4		Students entering the classroom and finding seats	NA	NA	NA	NA
12:39	12:44	5		Administrative tasks—students working on bell ringer	NA	NA	NA	NA
12:44	1:00	16	55.17%	Whole-group review of bell ringer	3	2	2	2
1:00	1:03	3		Directions	NA	NA	NA	NA
1:03	1:05	2	6.90%	Small group 1	3	3	3	2
1:05	1:07	2	6.90%	Whole-group discussion	2	2	2	2
1:07	1:10	3	10.34%	Small group 2	3	3	3	2
1:10	1:16	6	20.69%	Whole-group discussion	2	2	2	2
1:16	1:17	1		Packet pick-up	NA	NA	NA	NA

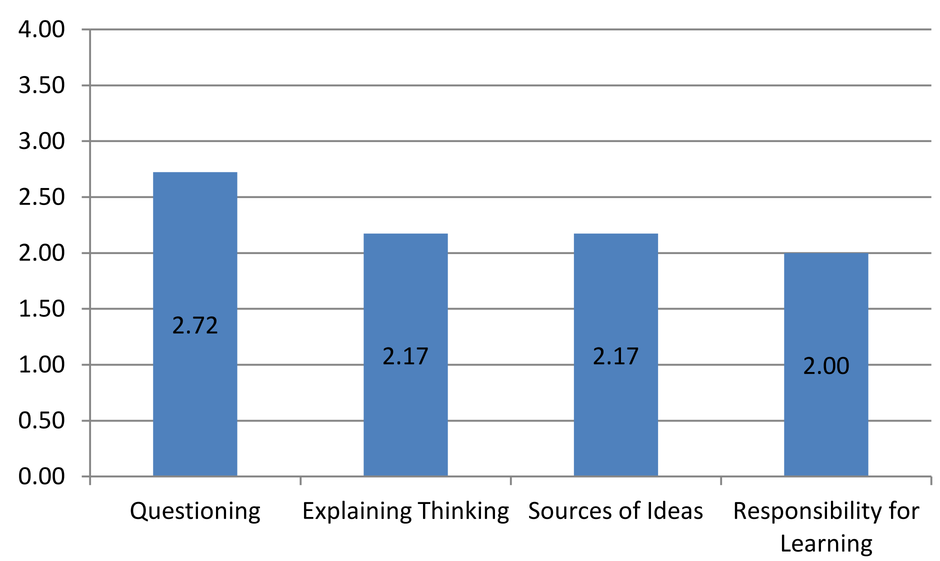

Figure 10. Ms. Anderson's April 2, 2015 Math Talk Community weighted scores.

The Marshall (2013) instructional factors were able to distinguish between the whole-group warm-up debrief, the small-group debrief sessions, and the small-group discussions. Again, while the teacher made attempts to engage students in rich discussions, she was not consistently successful, which resulted in slightly lower ratings than might have been if classroom management was stronger and a culture of learning and respect were in place. Thus, *teacher role* and *student role* were scored at Levels 2 and 3 because of these attempts. *Knowledge acquisition* for whole-group discussion was scored as Level 2 because the problems addressed writing and solving one-step equations, which was a review. It was scored as Level 3 for the small-group discussions because students were working with new applications. Note also that the whole-group debrief following the small-group discussions was at a lower level than the initial whole-group debrief. In that first whole-group discussion, Ms. Anderson took time for students to share their ideas and solutions on the board and verbally. She seemed more rushed during the later whole-group discussions and simply had students share their answers in a more didactic and abbreviated manner. For example, in the first discussion, Ms. Anderson invited students to share their ideas:

Ms. Anderson: Explain to me how to work number one.

Student: What?

Ms. Anderson: Come show me what you mean [points to the whiteboard at the front of the room].

Student: [Goes to board and shares her work.]

This segment was scored at Level 3 for *instructional strategies* and *order of instruction,* but later sessions were only scored at Level 2 because of the more controlled, didactic sharing of responses.

The small-group discussion opportunities were very interesting. Ms. Anderson directed the students:

> Look at page 9C. Look at question one. Look at answer choice A…. See if you can write an equation from that information. You may speak with the people at your table quietly. I am going to give you about two minutes to write an equation with x.

During the small-group discussions, a few groups were observed discussing the problems and possible equations:

Student 1: Because it says the sales price is $4.75, the discount is 3.50. x is the original price.

Teacher: [Provides verbal discipline to the class.]

Student 2: It is. You got to look at…

Student 1: ‘Cause the original price minus the discount is equal to the sale price.

Due to this type of exchange in some of the small groups, the *instructional strategies* indicator was scored at Level 4, but the *order of instruction* indicator was only scored at Level 3. *Knowledge acquisition* was scored at Level 2 because the concepts being discussed were review. *Teacher role* and *student role* were scored at Levels 3 and 2, respectively. These scores should have been higher with such a strategy, but because of the constant student interruptions and off-task behavior, Ms. Anderson was not able to be effective in facilitating student discourse as she might have been otherwise. See the summary of scores in Table 31.

Table 31

Ms. Anderson's April 2, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Whole-group review of bell ringer	3	3	2	2	2
Small group 1	4	3	3	2	3
Whole-group discussion	2	2	2	2	2
Small group 2	4	3	3	2	3
Whole-group discussion	2	2	2	2	2

Within discourse factors, there was again a scoring difference between the segments. Attempts by Ms. Anderson to engage students in the first whole-group discussion were more frequent and more successful, resulting in an increase from Level 2 to Level 3 for *questioning level* and *complexity of questions,* as well as an increase from Level 1 to Level 2 for *communication pattern* and *classroom interaction*. The increase in the discourse factors was demonstrated when she invited students to the whiteboard to share their work with the rest of the class. All *questioning level* scores were rated at a Level 2 because the individual problems or problem parts explored by students were skill-based. However, in the last whole-group discussion, when the problem was put together, the *questioning level* reached an analysis—Level 3:

Ms. Anderson: [Reads the problem.] D says Amy completed a math problem in 3.5 minutes. Geovany complete the same problem in 4.75 minutes. The time limit was five minutes. What is x, the difference in Amy's time and the time limit. Ohhhh. So x equals the time limit. So x equals the difference in Amy's time and the...

Student: [Interrupts] 3.5.

Ms. Anderson: 3.5 and the time limit. What's the time limit?

Student: Five.

Ms. Anderson: What was it? The limit was five minutes, so what do we do? How do we find the difference in that?

Student: Subtract.

Ms. Anderson: Subtract. So it would be five minus what?

Student: 3.5.

Ms. Anderson: 3.5. Okay. Now go back up and read your problem. Your problem says, "Which situation is best represented by the equation below? x minus 3.5 equals 4.75." Did we write that exact equation anywhere?

Ms. Anderson continues to help students compare and analyze the different equations they had written to determine which one would be equivalent to the equation in the problem.

The small-group discussions were rated at Level 3 for *complexity of questions*, *questioning ecology*, and *communication pattern*. Again, these scores might have been higher, but the last two were dependent on a sufficient number of students being on the task as assigned by Ms. Anderson. However, *classroom interactions* were scored at Level 2 because of the lack of participation by many students in the discussion. Scores are displayed in Table 32.

Table 32

Ms. Anderson's April 2, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Whole-group review of bell ringer	2	3	2	2	2
Small group 1	2	3	3	3	2
Whole-group discussion	2	2	2	1	1
Small group 2	2	3	3	3	2
Whole-group discussion	3	2	2	1	1

Observer reflections

Ms. Anderson was using the correct techniques, but seemed unsuccessful in fully engaging the majority of students in the discussions. There may be several reasons: time of day, time of year, classroom management, and/or classroom culture. I attempted to continue to encourage Ms. Anderson's attempts, but also helped her incorporate classroom management structures.

Observation 4: April 16, 2015 / sixth period

General observations

Ms. Anderson's class consisted of seven separate segments. The first segment consisted of the process of students entering the classroom and finding their seats and papers. The second segment was an extended eight-minute period in which Ms. Anderson was attempting to prepare the Kahoot lesson and admonishing students for talking. (Kahoot is a game-based learning platform on which Ms. Anderson had prepared some multiple-choice questions for students.) The third segment was a Kahoot review of statistical concepts and vocabulary, which included a question, student response, revealed correct response, and whole-group discussion of the correct response. There were more directions in the fourth segment. During the fifth segment, students were given six minutes to review and discuss their homework answers with their partners before the sixth segment of another round of Kahoot to randomly check the homework answers. The second segment of Kahoot was conducted similarly to the first, where students discussed the possible correct answer, entered their answer, waited for the correct answer to appear, and then listened to a whole-group discussion about the correct answer (and at times some of the incorrect answers). However, during this Kahoot segment, students appeared to spend much less time discussing the possible solution and simply entering an answer or guess.

Student discourse observations

The first Kahoot review was scored at Level 2 for *questioning, explaining mathematical thinking,* and *responsibility for learning* because the teacher was prompting students to respond, but asked some probing questions and attempted to get students listening to each other, as evidenced by one student asking if he could help. The same segment was scored at Level 3 for *sources of mathematical ideas* because the teacher did not launch into lecture, but rather asked questions and had students discuss and respond. In the review of the responses, Ms. Anderson asked for explanations from students, at times referring them to an anchor chart posted with the information.

Ms. Anderson: Okay, only four people (pairs) knew the answer.

Students: [Groan, mumble.]

Ms. Anderson: [Interrupts discussion for disciplinary actions.] Raise your hand and explain what the question is asking. What is the question asking? Tim?

Tim: If a question has variability

Ms. Anderson: If a question has variability—what is that asking?

Tim: It has more than one...

Ms. Anderson: [Interrupts discussion for disciplinary actions.]

Tim: It has more than one answer.

Ms. Anderson: It can have more than one answer.

Students: Ohhh.

During the segment in which students were engaged in partner talk about the prior evening's homework, the Math Talk Community scores were not as high as they could have been for two reasons: (1) the teacher was sitting at her desk preparing the next Kahoot and (2) only 15 of the 27 students were actually discussing the problems. For those reasons, *questioning* was scored at Level 4, but *explaining mathematical thinking, sources of mathematical ideas,* and *responsibility for learning* were all scored at Level 3. If the teacher had been more effective at classroom management and/or facilitating rich mathematical discussion, the structure she attempted to put in place would have been much more successful and scored at the highest level.

The final Kahoot segment was slightly different. During this segment, the students were responding with their partner to Kahoot questions about the solutions to different homework problems. The Kahoot program asked the question, and Ms. Anderson had the timer set for 2.5 minutes. However, the students did not appear to discuss the question but rather quickly entered their answer choice and waited for the timer to run out and the correct response to be revealed. Depending on the number of correct responses, Ms. Anderson would launch a discussion about the problem. She would ask, "Explain how you did it," "Show me," "What does that mean?", and "Who can explain how it works?". The following is an example of one exchange:

Ms. Anderson: Who can explain why that is the answer?

Student: You use the median because it is skewed.

Ms. Anderson: How do we know it's skewed Because it's not what?

Student: Even.

Ms. Anderson: And if it were even, what would that mean? What's the word?

Student: Symmetric.

Ms. Anderson: So if it's skewed, the better way to find the...what are we looking for?

Student: Center.

Ms. Anderson: The center. So the best way to find the center is the what?

Students: Median.

Ms. Anderson: So how do we find the median? [Interrupts discussion for disciplinary actions.]

Many of the students participated in the discussions as facilitated by the teacher, and a student or students provided information if they did not agree with another student's response. For this reason, *questioning* and *source of responsibility for learning* were scored a Level 3. Again, if Ms. Anderson had been a bit more effective in engaging the entire group of students, the Math Talk Community scores would most likely have been higher (see Table 33 and Figure 11).

Table 33

Ms. Anderson's April 16, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
12:37	12:40	3		Students entering the classroom and finding seats	NA	NA	NA	NA
12:40	12:48	8		Administrative tasks—directions	NA	NA	NA	NA
12:48	12:54	6	22.22%	Partner/whole-group Kahoot bell ringer	2	2	3	2
12:54	12:55	1		Directions	NA	NA	NA	NA
12:55	1:01	6	22.22%	Partners discussing homework	4	3	3	3
1:01	1:02	1		Directions—getting Kahoot started	NA	NA	NA	NA
1:02	1:17	15	55.56%	Kahoot homework discussion	3	2	3	2

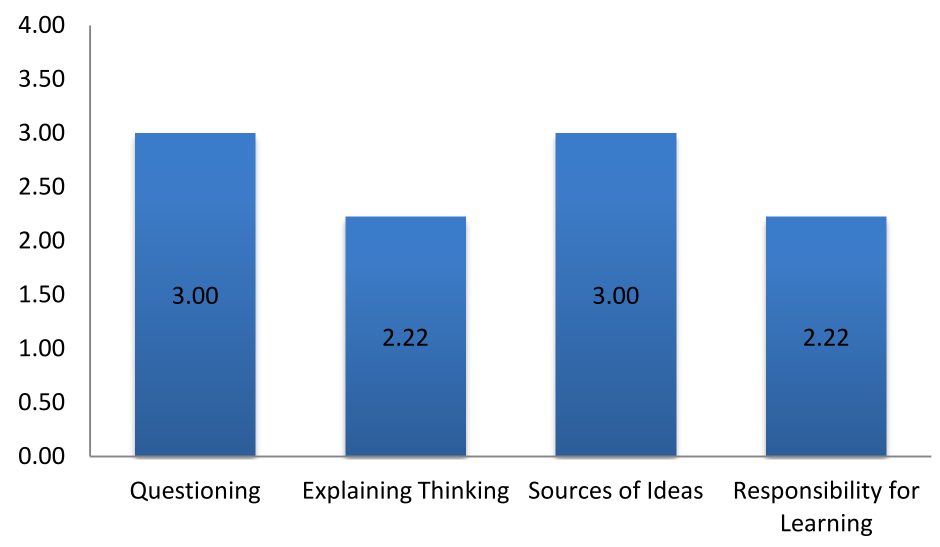

Figure 11. Ms. Anderson's April 16, 2015 Math Talk Community weighted scores.

Using Marshall's (2013) instructional factors rubric to rate the lesson, most of the factors, except *order of instruction*, were rated at Level 3 (see Table 34). The *instructional strategies* indicator for the bell-ringer review segment was Level 2 because the entire purpose of the partner discussion and the two Kahoot segments were to verify responses. However, the questioning Ms. Anderson conducted probed more into the conceptual understanding behind the responses. *Teacher role* and *student role* were rated at only a Level 3 rather than a Level 4 because, as mentioned previously, Ms. Anderson was ineffective in engaging a large enough group of students in the discussions. The only Level 2 score was for *knowledge acquisition* for the bell-ringer review. Those questions reviewed vocabulary, and students could have used the definitions posted on the wall. *Order of instruction* for the small-group discussion of homework and the whole-group review was a Level 4 because this was new material that the students had completed on their own and then discussed with peers prior to any teacher input.

Table 34

Ms. Anderson's April 16, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Partner/whole-group Kahoot bell ringer	2	3	3	3	2
Partners discussing homework	3	4	3	3	3
Kahoot homework discussion	3	4	3	3	3

Considering the Marshall (2013) discourse factors, Ms. Anderson attempted to raise the discourse ecology to a Level 4, but in most cases she was unsuccessful because of her ineffectiveness in engaging the students. *Questioning level* was generally scored at Level 3. However in the first segment, she really had to probe to encourage the students to explain their understanding and was never able to obtain real analysis. An example of such probing from the first segment is in the exchange below:

Ms. Anderson: Who can quickly explain what the question was about? What was the question was about?

Student: I read the question, I looked at the thing, and I put…

Ms. Anderson: I said, explain to me what was the question about.

Student: The distribution of the line plot.

Ms. Anderson: So that was question six. What does that mean? We had to look back at the line plot in number five.

Student: The distribution has a peak at six.

Ms. Anderson: So what does that mean?

Student: Yes, it's the peak.

Ms. Anderson So what does that mean?

Student: Where it rises.

Ms. Anderson: So where it rises is the highest?

Students: Ohhh.

Similarly, *complexity of questioning* was scored at Levels 2 and 3 because Ms. Anderson struggled to elicit reasons for student responses. However, she was able to maintain *questioning ecology* at Level 3 throughout the segments. Ms. Anderson was making attempts to engage students with open-ended questions, as seen in the exchange below. However, only a few students were sharing responses:

Ms. Anderson: We still have five groups that missed it. What's going on here? Someone explain how to work the problem. Can you tell me Tim?

Tim: Average.

Ms. Anderson: Find the what?

Tim: Average.

Ms. Anderson: How do we find the average?

Tim: I don't know.

Students: [Call out ideas.]

Ms. Anderson: Tim, I need you to say it. Mean and average is the same thing.

Tim: Add.

Ms. Anderson: [Waits.]

Tim: Divide?

Ms. Anderson: Yes, you add them all up and then you divide.

Communication pattern was scored at Level 2 for the Kahoot sessions because the teacher seemed to have to draw out any responses provided by students, except when one student volunteered to help another. The partner discussion over the homework was scored at Level 4 for the students who actually were on task, as they were having a conversation about the problems. *Classroom interactions* were all scored at Levels 2 and

3, reflecting Ms. Andersons' unsuccessful attempts to facilitate discussion. (See Table 35 for discourse factors.)

Table 35

Ms. Anderson's April 16, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Partner/whole-group Kahoot bell ringer	2	2	3	2	2
Partners discussing homework	3	3	3	4	2
Kahoot homework discussion	3	3	3	2	3

Observer reflections

Ms. Anderson continued to struggle with classroom management and managing transitions. It was 11 minutes into the class period before students began working together on mathematics. There were two one-minute intervals when directions were given and only 27 minutes in which students were on task doing mathematics. The Kahoot format was interesting to the students and they seemed excited to use it. However, they seemed to spend less time worrying about the mathematics and more time worrying whether they entered the correct answer or not. While 27 minutes were spent on task, only about six to 11 minutes were spent in mathematical conversations as students were supposed to be discussing their proposed answers to the Kahoot questions. Ms. Anderson used appropriate questioning and structures to facilitate rich discussions, but the students seem to struggle with following her directions and therefore did not benefit from her efforts as much as they could have. Students that did participate appeared to be discussing and learning mathematics, but disciplinary distractions meant less time was actually spent learning mathematics.

Summary of Student Discourse Observations Over Time

Ms. Anderson demonstrated an increase of one level in *questioning* and *source of mathematical ideas* from the Hufferd-Ackles et al. (2004) Math Talk Community. In the last two observations, Ms. Anderson demonstrated a more persistent questioning technique, and her students began to respond with more detail in their explanations. Because of this, Ms. Anderson did not need to supply ideas, but rather would repeat the explanations that students provided and, if needed, probed for more information. *Explaining mathematical thinking* and *responsibility for learning* did not show as much of a cumulative increase. Throughout the observed lessons, Ms. Anderson probed students for the thinking behind their answers, as indicated in the *explaining mathematical thinking* category. However, while some students did increase in their explanation, it was only due to Ms. Anderson's probing and not questions from the students. The same was true for the *responsibility for learning* category. While Ms. Anderson set up opportunities for and encouraged students to listen to each other, the majority of the students did not fully engage in the discussions. Her questioning technique and persistence in the later observations should have yielded better results. Note that the transcripts of mathematical conversations from the recordings did not include the disruptions and the numbers of students who were off task. Figure 12 illustrates the growth in *questioning* and *sources of ideas* and the relative lack of growth in the other two categories. Weighted ratings for each category are found in Table 36.

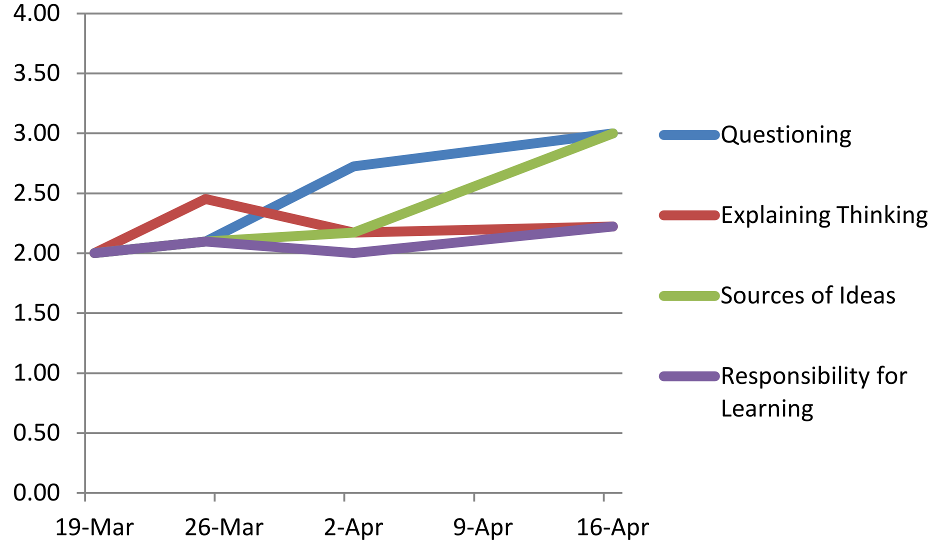

Figure 12. Ms. Anderson's Math Talk Community weighted scores over time.

Table 36

Ms. Anderson's Math Talk Community Scores Over Time

	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
03/19/15	2.00	2.00	2.00	2.00
03/25/15	2.10	2.45	2.10	2.10
04/02/15	2.72	2.17	2.17	2.00
04/16/15	3.00	2.22	3.00	2.22

Marshall's (2013) instructional factors are those five factors identified that describe the structures a teacher establishes in lessons that facilitate student learning of mathematics and science. The *instructional strategies* factor describes the format of the lesson—does the teacher use lecture to cover content in lecture or do students engage in activities that help them construct understanding? Ms. Anderson employed different strategies in each of the observed lessons, but she never actually lectured. The earlier lessons were more like a facilitated lecture, but later lessons had students exploring and sharing or explaining their ideas rather than Ms. Anderson's. The *order of instruction* factor specifically addressed the timing of the explanation of mathematics related to when students explored the ideas. If the teacher explained first, the *order of instruction* level would be rated lower than if students explored concepts and then the teacher and students explained the concepts. The *order of instruction* in Ms. Anderson's lessons began higher than other factors and increased to almost the highest level. This result demonstrates a shift in Ms. Anderson's planning to allow students to explore ideas rather than be taught in a traditional format of her describing the mathematical concepts and asking students to repeat them back to her. *Teacher role* and *student role* should mirror each other as a teacher gradually transitions to a facilitator and students become more actively engaged in learning. As mentioned earlier, Ms. Anderson struggled with classroom management with this group of students. She attempted to set up the structure for increasing the engagement of students and increasing her role as facilitator in the learning. She was able to demonstrate almost two levels of increase in these two factors. She would have achieved even more had all the students been as engaged as the core group. However, Ms. Anderson did not demonstrate growth in the *knowledge acquisition* factor. The resources used and Ms. Anderson's ability to increase student thinking to higher cognitive levels with those resources dictated this rating. Ms. Anderson, like most other teachers observed at this campus, appeared to be aiming for a certain cognitive level, which was lower than the highest level on the Marshall (2013) *knowledge acquisition* factor. Overall, there was growth demonstrated in Ms. Anderson's lessons related to the instructional factors, as illustrated in Figure 13. The variation in these scores is interesting, but I believe they may have resulted from Ms. Anderson attempting different strategies for each lesson—perhaps in an attempt to increase discourse ecology or in an attempt to engage all her students in learning mathematics. (See Table 37 for instructional factors over time.)

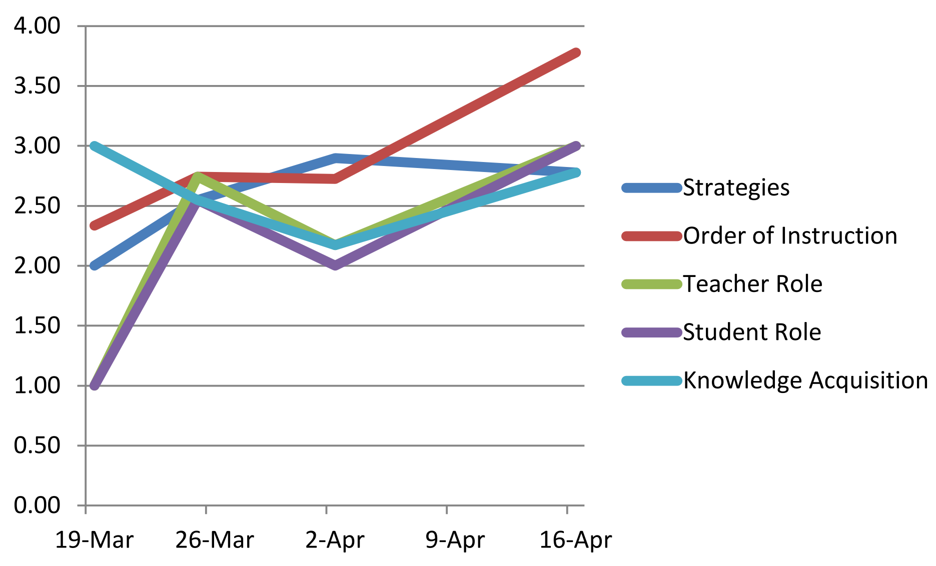

Figure 13. Ms. Anderson's instructional factor weighted scores over time.

Table 37

Ms. Anderson's Instructional Factors Over Time

	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
03/19/15	2.00	2.33	1.00	1.00	3.00
03/25/15	2.55	2.74	2.74	2.55	2.55
04/02/15	2.90	2.72	2.17	2.00	2.17
04/16/15	2.78	3.78	3.00	3.00	2.78

In Ms. Anderson's various strategies and attempts over the four observed lessons, significant growth was not observed in most of the discourse factors (Table 38 and Figure 14). The exception was *classroom interactions*. This increase was due to the increased persistence Ms. Anderson demonstrated in her efforts to get the students to explain their processes and thinking about mathematics. At first, Ms. Anderson seemed rushed to tell students the mathematics, but over time she seemed to stick with her questioning until at least some students were able to describe their understanding of the mathematical concepts and she provided less and less information. I believe that she would have been able to get students questioning other students in the near future with more practice, especially when her classroom management improved.

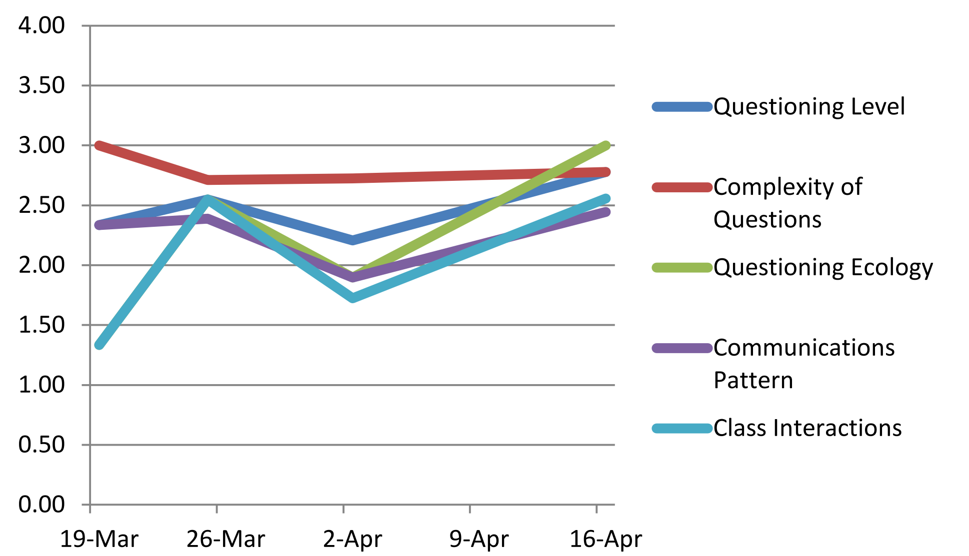

Figure 14. Ms. Anderson's discourse factor weighted scores over time.

Table 38

Ms. Anderson's Discourse Factors Over Time

	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
03/19/15	2.33	3.00	1.33	2.33	1.33
03/25/15	2.55	2.71	2.55	2.39	2.55
04/02/15	2.21	2.72	1.90	1.90	1.72
04/16/15	2.78	2.78	3.00	2.44	2.56

Post-Intervention Perceptions and Beliefs

During conversations, Ms. Anderson expressed her uneasiness with large groups of students and her preference for working with students in very small groups. She hoped that she would be able to return to her interventionist role soon. In fact, Ms. Anderson shared one reason for not being able to keep up with the intervention reflections—she was working on her master's degree in instructional technology and library science in her free time. It seemed that Ms. Anderson's long-term goal was not classroom instruction.

After the March 25, 2015 lesson, Ms. Anderson responded to reflection questions about strategies and her needs as a teacher in implementing these strategies. She stated that she had intended to have students talk more in groups to share their responses. While she was somewhat successful and her students were more engaged than usual, she felt they needed to practice using more vocabulary. She also requested assistance with time and classroom management. When Ms. Anderson was working through the online course, she stated, "Student discourse gives the students ownership of their learning and ideas, and holds them responsible for being able to communicate these with others."

Conclusions About Changes in Beliefs and Instructional Practices

It was difficult to assess changes in Ms. Anderson's beliefs. She struggled to complete the additional reflection she was asked to do in the intervention. While she responded to some questions, she did not submit her final reflection questions. She responded to initial questions about demographic information and prior training. She submitted a post-lesson reflection and some verbal impressions. Ms. Anderson also contributed to the online course reflections toward the end of the intervention. She contributed very little to the PLC conversations as well. She spoke up only once in the first PLC session on March 25, 2015 and four times in the second PLC on April 2, 2015.

The theme characterizing her contributions in the second PLC was concern about students not being able to understand the concepts.

Changes in Ms. Anderson's instruction were also a bit difficult to assess. During each observed lesson, she tried a new seating arrangement, new student groupings, and new instructional strategies. She had expressed her uneasiness with large groups of students. It seemed that as the intervention progressed, she was trying different approaches to reach the students and engage more of them in learning. Conversations, submitted reflections, and Ms. Anderson's prior work as an interventionist revealed that she knew very well what students needed to do to learn mathematics. Trying new strategies and noticing the levels of student engagement (or not) seemed to keep Ms. Anderson looking for a better approach to solve her problems with classroom management and student engagement. The one clear area of growth Ms. Anderson demonstrated was her increased ability to persist in probing students to share their mathematical ideas and reasoning. Toward the end of the intervention, she provided little in the way of mathematical information, but facilitated students sharing the information. If she had been working with a smaller group of students or if the class had demonstrated fewer disciplinary issues, her instructional approach would have been a model for questioning facilitation.

By the end of the intervention, Ms. Anderson was using the techniques and strategies suggested to her through feedback and in the online training. Her ability to engage her students in mathematical discussions did improve somewhat, as she moved from a questioning-lecture format to a variety of other formats that allowed for much more small-group, student-to-student discussion. If we were to consider her strategies and questioning in isolation, Ms. Anderson would have scored very high on discourse ecology. However, it appeared that using the appropriate strategies was not enough to ensure quality student discourse without other basic structures in place—respectful classroom climate and management.

The Case of Ms. French

Background

Ms. French is a White teacher in her 40s with 24 students in the class period I observed: 20 African-American students (12 boys and eight girls) and four Latino students (three boys and one girl). This was her first year at Southeast STEM Center and in the district. Prior to the intervention year, she had nine years of teaching experience in nearby and larger districts. Her most recent experience was in a district that had embraced the Project-Based Learning (PBL) format. She expressed how much she enjoyed that way of teaching. Ms. French expressed respect for her students, who were all African-American or Hispanic. She seemed to connect with the students and participated eagerly in the intervention, as well as the PLC sessions. At the end of the intervention, Ms. French shared that the principal at the campus had decided not to renew her contract for the next school year.

Ms. French had participated in a face-to-face session with me hosted by her district earlier in the year on a professional development day. She shared that she recalled there being different levels of student discourse and even remembered the rubric shared. She also recalled that the rubric addressed the progression “from being entirely teacher dictated to almost completely student led and initiated.” While she recalled the training, she had not attempted any of the strategies from the training.

Pre-Intervention Perceptions and Beliefs

Ms. French responded to the discourse beliefs reflection questions on March 22, 2015. When asked what discourse means to her, Ms. French responded, “Written or verbal communication.” When asked why she might want to increase her awareness of discourse patterns in her classroom, she felt that her role was to guide and release, as well as get students talking more. She also shared that she felt that her role as a teacher was to be a facilitator, educator, and motivator. In response to the question about her role in classroom discussions, she stated, “Providing opportunities in small groups to discuss concepts, partner work, journaling, presenting to class.” She also shared her goals to help students improve their metacognitive experiences. She concluded by sharing her equation for understanding mathematics: “conceptual understanding + computational accuracy = mathematical fluency.”

Individual Lesson Observations, Discussion, and Scoring

Observation 1: March 19, 2015 / seventh period

General observations

When I entered the classroom, Ms. French was at her computer and the students were working on the bell-ringer warm-up. She called students’ names and they responded orally to the roll call. She then passed out homework papers as she reminded students about their responsibilities and, at times, chided them for not turning in work. It seemed to take several minutes before the lesson began. Ms. French lapsed into this kind of reminder lecture several times throughout the class period. During the body of the lesson, Ms. French guided the students through a few geometry application problems. Her support in solving the problems showed a gradual decrease in support and an increase in peer discussions during the problem-solving. The class ended with Ms. French collecting papers and reminding students about homework and their responsibilities again.

Student discourse observations

The coding for the Math Talk Community was divided into several segments in order to obtain a better discrimination between the differences in the levels. For Math Talk Community, there were 10 separate identifiable segments. The first segment was administrative and involved taking roll, passing back papers, and lecturing students on responsibilities. The remaining nine segments were either whole-group discussions or small-group discussions. The level of Math Talk Community was very similar for all except the first and last whole-group discussions. The small-group discussions demonstrated identical levels of Math Talk Community. During whole group, Ms. French was the main questioner, but students asked questions as well:

Ms. French: All right come back to me. I've got somebody who is going to explain what just happened. I have a volunteer to explain what just happened. Y'all listen to him please.

Student 1: So on this one you add that because you can subtract it again to get the difference between the two.

Students: [Talk.]

Student 2: I don't understand.

Ms. French: So he was saying 840 minus 210 equals 630 because inverse operation tells you the opposite of subtraction is what?

Students: Addition.

Ms. French: 210 plus 630 equals 840. Jasmine do you have a question?

Jasmine: I don't understand.

Students: [Call out information to assist Jasmine.]

She occasionally launched into a lecture mode, but more so in the first whole group. Consequently, the first segment was scored Level 2 for *questioning* and Level 3 for the remaining whole-group segments.

Student 1: Wait, wait, wait, wait, wait. It says triangle, one-half, one-half base times height. Base times height. We're doing all sides. So that's not right.

Students: Ohhh.

Student 2: But the thing says twice, so we have to double because it says twice as large.

Student 3: Exactly.

Student 2: So we have to double all of these.

Throughout the lesson, with the exception of the last whole-group segment, Ms. French probed students' thinking but was not able to elicit strategies, even during the small-group discussions. This resulted in a Level 2 score for *explaining mathematical thinking*, with the exception of the last segment in which students explored strategies. Similarly, during the whole-group discussions, Ms. French was the main *source of mathematical ideas* (Level 2) until the last whole-group segment when she followed up on student explanations and attempted to have students build on each other's ideas (Level 3). However, the *responsibility for learning* during whole group included opportunities for students to consider other students' ideas (Level 2), but she began to shift the responsibility to students as she had them engage in small-group conversations (Level 3). (See Table 39 and Figure 15 for Math Talk Community scores.)

Table 39

Ms. French's March 19, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
1:23	1:29	6		Administrative procedures	NA	NA	NA	NA
1:29	1:33	4	5.71%	Whole-group discussion	2	2	2	2
1:33	1:35	2	5.71%	Small group	3	2	3	3
1:35	1:41	6	17.14%	Whole-group debrief	2	2	2	2
1:41	1:42	1	2.86%	Small group	3	2	3	3
1:42	1:48	6	17.14%	Whole-group debrief	2	2	2	2
1:48	1:49	1	2.86%	Small group	3	2	3	3
1:49	1:51	2	5.71%	Whole-group debrief	2	2	2	2
1:51	1:57	6	17.14%	Small group	3	2	3	3
1:57	2:06	9	25.71%	Whole-group debrief	2	3	3	2

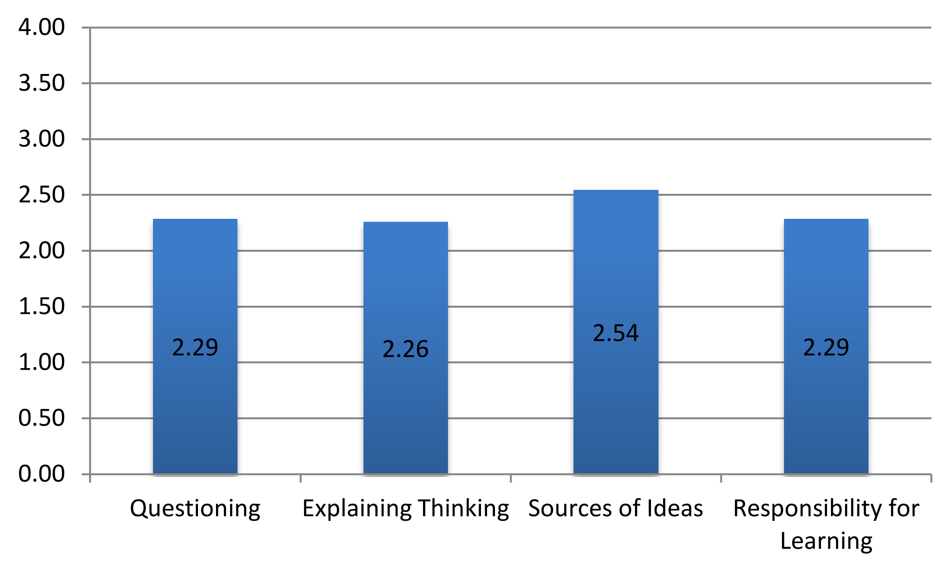

Figure 15. Ms. French's March 19, 2015 Math Talk Community weighted scores.

As with the Math Talk Community, the whole-group and small-group segments were coded very similarly with the Marshall (2013) instructional indicators (Table 40). The whole-group/small-group discussion was at a Level 2 for *instructional strategy* and *order of instruction* because Ms. French used a worksheet of problems to guide the discussion, and much time in both whole-group and small-group was devoted to determining the correct solution. Ms. French occasionally lectured, and as such was the center of the lesson, although she also acted as facilitator at times and during the brief small-group discussions. This resulted in a Level 3 score for *student role* and *teacher role* during whole group, but a Level 4 during the small group when students guided the discussions. The *knowledge acquisition* indicator was rated at Level 3 throughout the whole-group and small-group discussions because the students were required to apply their knowledge in new problems.

Ms. French: Five, four, three, two, come back to me, one. Raise your hand if you think you have an answer. Without a pencil, this is all brainwork. Using your eyes and the power of your brain, what did you think Jay? Why did you pick J?

Jay: Uh, um, because, um 12 um. How can I explain with everybody looking at me?

Ms. French: You can explain.

Jay: 12.4 centimeters is because, I don’t know, the trapezoid, the answer is 20.3 and um...

Ms. French: Do you want some help?

Jay: Yeah.

Ms. French: Sandra, help him out.

Sandra: 12.4, what he said, 'cause 12.4 is the base and 20.3 is the other base so you add them together and then you divide by two.

Ms. French: Miley, tell us why J is the correct answer.

Miley: J, because um, on one side it's eight centimeters.

Ms. French: The height, okay.

Miley: But on the left side it's 11.3.

Ms. French: That's the slant, and we don't measure height on the slant, remember?

Table 40

Ms. French's March 19, 2015 Instructional Factors

Student Actions	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Administrative procedures	NA	NA	NA	NA	NA
Whole-group discussion	2	2	3	3	3
Small group	2	2	4	4	3
Whole-group debrief	2	2	3	3	3
Small group	2	2	4	4	3
Whole-group debrief	2	2	3	3	3
Small group	2	2	4	4	3
Whole-group debrief	2	2	3	3	3
Small group	2	2	4	4	3
Whole-group debrief	2	2	3	3	3

Throughout whole-group and small-group segments of the lesson observation, Ms. French asked the students to consider their understanding and at times apply their knowledge of area, resulting in a Level 3 for *questioning level*. Similarly, *complexity of questions* and *questioning ecology* for the whole-group discussions were at Level 3, reflecting Ms. French's requirement that students provide explanations for their statements. When small groups reported their discussions, she asked, "What were you thinking about this problem?". In the small-group discussions, students held each other accountable and/or volunteered their explanation in order to convince their peers, resulting in a Level 4, as evidenced in the small-group conversation above.

Communication pattern and *classroom interactions* were slightly lower for the whole-group (Level 2) and small-group discussions (Level 3), as Ms. French attempted to provide for a conversational format but still attempted to maintain control. This desire for control was demonstrated when students would call out answers and she kept stopping them and required that they raise their hands or simply called on students who did not have hands raised to force a response. (See Table 41 for discourse factors.)

Table 41

Ms. French's March 19, 2015 Discourse Factors

Student Actions	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
Administrative procedures	NA	NA	NA	NA	NA
Whole-group discussion	3	3	3	2	2
Small group	3	3	3	3	3
Whole-group debrief	3	3	3	2	2
Small group	3	3	3	3	3
Whole-group debrief	3	3	3	2	2
Small group	3	3	3	3	3
Whole-group debrief	3	3	3	2	2
Small group	3	3	3	3	3
Whole-group debrief	3	3	3	2	2

Observer reflections

The students in Ms. French's class also seemed to be restless, but enjoyed the brief periods when they were able to share in their small groups. Ms. French would launch into lecture mode about the students' responsibilities and how they needed to be more organized and work harder if they were going to be successful. It seemed as if a lot of class time was spent focusing on this activity. However, Ms. French also attempted a few different approaches, allowing students to discuss within their small groups as she circulated and made suggestions or asked questions. As I circulated to monitor discussion, I noticed that the students seemed unprepared for the work they were attempting. For example, in a problem in which they were to determine the difference in the areas of an original triangular figure and one with double the dimensions, many students began by simply multiplying the lengths of all sides. After discussion in their groups, most remembered the formula and found the area of the original triangle. However, almost none of the students were able to double the dimensions and find the second area or find the difference of the two areas.

Feedback

I was unable to provide immediate feedback as there was no class break: at the bell, students were to launch into a reading review for the upcoming Reading STAAR. In e-mail feedback, I praised Ms. French's attempts to let students discuss in groups and suggested that she consider providing a bit more guidance or structure to the discussions. For example, she could consider assigning roles to the students for discussions and other group work. She might also consider ways of holding individual students accountable for their roles in the small-group discussions. For example, each student could turn in a brief description of the discussion or their own version of the problem solution. In this way she might increase student engagement and accountability during the small-group discussions.

She responded positively to my suggestions and shared that she enjoyed using the PBL format from her last district and felt that would provide some of the structure students needed.

Observation 2: March 25, 2015 / seventh period

General observations

Ms. French used a basic structure in her small groups during this lesson. She had created three student roles: record, solve, and repeat. The first student was to read the problem and describe what the problem was about. The second student was to solve the problem and discuss with the first student. To recap the work, the third student was to restate the solution. As students adjusted to the structure, their conversations became more focused on the mathematics, and they held each other more accountable:

> Ms. French: You have a piece of paper on your table that says record, solve, [and] repeat. So you are going to get into groups of three. If you are not in a group of three, you might get that way. Today you are going to take ownership of your learning, and everyone is going to take part in it. So you are going to work as a group today. So when you are reading a problem, someone is going to read it and record what you know. And you have a discussion: what do you know about this, what do you need to know. Someone is going to solve the problem. So maybe in this case Jesse reads the problem and says, "Okay guys. We know it says this, we need to know this," and then he hands it over to Bobby and he says, "Based on what we know and need to know Bryant is going to solve it." And then, they talk about it together and then they had it over to Daniel and he talks about it. So if he's not real familiar with it, then he says, "Okay

> Daniel, we know this and we need to know this, and you solved it this way and that's how we got the answer." So every single person has a role in the problem-solving process. Everyone is responsible for their own learning.

The only issue seemed to be with groups of three very close physically to other groups, which tended to make up a group of six; the size of the group appeared to impact the effectiveness of this technique as compared with actual groups of three. Several students were absent because they had a band commitment at the beginning of class, but arrived part of the way through, which did disrupt the grouping structures somewhat.

Student discourse observations

After an administrative segment in which roll was taken and directions were given, the remainder of the class consisted of four separate small-group conversations about a problem lasting from four to seven minutes, followed by whole-group debriefs lasting from two to five minutes. There seemed to be several interruptions during the class period: phone calls, a student leaving and coming back, and then several students coming in from being out for band.

The patterns of communication varied somewhat in the small groups and whole group. For example, during the first small group discussion, the small groups observed appeared to spend about half the time provided getting accustomed to the structure.

Ms. French: Go ahead and start. Remember your roles.

Small Group 1

Sam: I'll read, you solve, you solve.

Andrew: I don't want to do that!

Sam: Ok, you be the solver (speaking to Adrian).

Andrew: You've already solved it.

Sam: I'll solve it.

Adrian: I'll read it.

This left only a minute to work the problem, not allowing the depth achieved in some of the following small group discussions.

During each successive small group discussion, except those groups interrupted by the addition of band students, the students more efficiently familiarized themselves with problems resulting in deeper conversation. Similarly, the whole group debrief discussions seemed to be more supported by teacher questioning and explanations in the beginning and the student responses demonstrated higher level thinking. Using the Hufferd-Ackles et al. (2004) rubric to assess the levels of Math Talk Community during each of the small group discussion segments, sources of mathematical ideas increased from Level 2 to Level 4, as seen in Table 42. As mentioned the discussions began at lower levels but increased in quality over time as the students adjusted to the roles and were provided additional time to discuss. Still, explaining mathematical ideas was only scored at Level 2 or 3 because, at times, the students were focused on getting an answer and but not necessarily figuring out why they got a certain solution. The initial whole group debrief segment was scored at a Level 2 in all categories: explaining mathematical thinking, sources of mathematical ideas, responsibility for learning, and questioning.

However, scores gradually increased until all categories for the final whole group debrief segment were at Level 3.

Table 42

Ms. French's March 25, 2015 Math Talk Community Scores

#	Start Time	Stop Time		Percent	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
1	1:22	1:29	7		Administrative procedures	NA	NA	NA	NA
2	1:29	1:33	4		Directions for small group	NA	NA	NA	NA
3	1:33	1:39	6	15.00%	Small group 1	3	2	2	3
4	1:39	1:41	2	5.00%	Whole-group debrief 1	2	2	2	2
5	1:41	1:45	4	10.00%	Small group 2	4	2	3	3
6	1:45	1:50	5	12.50%	Whole-group debrief 2	2	3	2	3
7	1:50	1:57	7	17.50%	Small group 3	4	3	4	4
8	1:57	2:02	5	12.50%	Whole-group debrief 3	3	3	3	3
9	2:02	2:09	7	17.50%	Small group 4	4	2	4	3
10	2:09	2:13	4	10.00%	Whole-group debrief 4	3	3	3	3

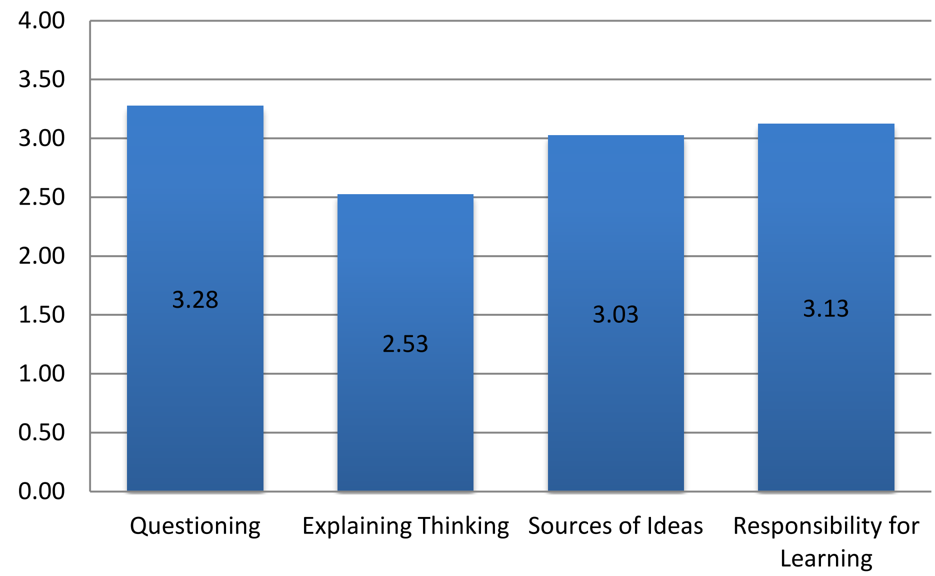

Figure 16. Ms. French's March 25, 2015 Math Talk Community weighted scores.

Using Marshall (2013) indicators to score instructional factors and discourse factors we see a similar pattern. Whole group exchanges were rated at or a level below small group discussions, with the majority of ratings being Level 2 or Level 3 with a few Level 4scores. The Level 4 instructional factors were teacher role in the small group discussions as Ms. French planned and facilitated these segments to be student-focused discussions. The *knowledge acquisition* indicator was rated at Level 2 for the first problem and discussion, but the remaining problems were judged to be more difficult and required students to solve by applying their understanding of integer operations. Some student groups were off task or struggled with the subject matter, resulting in some factors being scored lower.

During the third whole-group debrief, Ms. French asked a student to explain how he got his answer. She followed up his explanation with two additional requests for alternative strategies:

Ms. French: Tim, let's hear it all from the beginning. Listen carefully.

Tim: My group, we was looking at the…

Ms. French: Y'all had a great discussion when I was over there. I just want you to convey to them what your thought process was as a group so they understand how to solve those problems.

Tim: Okay, when I was solving it, I was looking at F and, 'cause it said it was going up by eight, so I looked at the one that has a positive two times a negative eight equals to negative 16 plus, times, a positive times a negative always gives you a negative.

Ms. French: Excellent, so if you look at that particular model. It starts on zero, it jumps back negative eight, which has an absolute value of what?

Students: Eight.

Ms. French: And you jump back another negative eight, which has an absolute value of what?

Students: Eight.

Ms. French: Eight spaces. Remember, if you jump from zero to negative eight, that's eight spaces, and if you jump from negative eight to negative 16, that's another eight spaces. But is it absolute value spaces or how far you are from zero?

Students: How far you are from zero.

[Description continues in this way.]

Ms. French: Did any other group solve that in a different way than Tim explained?

Maria: I did!

Ms. French: Maria, explain what your group did. Listen, we take turns.

Maria: We had uh, negative eight multiplied by two and we got negative 16.

Ms. French: Negative eight times two. That is one way you could have seen it! Billy tell them what you did.

Billy: So we said it was 16 because that's where it stopped at and we seen these two, two jumps.

Ms. French continued to ask for alternate strategies, which raised the level of *teacher role* for this whole-group debrief. (See Table 43 for instructional factors.)

Table 43

Ms. French's March 25, 2015 Instructional Factors

Student Actions	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Administrative procedures	NA	NA	NA	NA	NA
Directions for small group	NA	NA	NA	NA	NA
Small group 1	3	3	4	3	2
Whole-group debrief 1	2	3	2	2	2
Small group 2	3	3	4	3	3
Whole-group debrief 2	3	3	2	2	3
Small group 3	3	3	4	4	3
Whole-group debrief 3	3	3	3	3	3
Small group 4	3	3	4	4	3
Whole-group debrief 4	3	3	2	2	3

Discourse factors showed less variation. *Questioning level* was dictated by the cognitive level of the problem being discussed and tended to match the *knowledge acquisition* instructional factor. The remaining discourse factors fluctuated between Levels 2 and 3, depending on whether it was a small-group discussion or whole-group debrief. Ms. French's persistent questioning and searching for other solution strategies (described above) also increased *questioning ecology* and *communication pattern* for that whole-group discussion to Level 3. (See Table 44 for discourse factors.)

Table 44

Ms. French's March 25, 2015 Discourse Factors

Student Actions	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Class room Interactions
Administrative procedures	NA	NA	NA	NA	NA
Directions for small group	NA	NA	NA	NA	NA
Small group 1	2	3	3	3	3
Whole-group debrief 1	2	2	2	2	2
Small group 2	3	3	3	4	3
Whole-group debrief 2	3	2	3	2	2
Small group 3	3	3	3	4	3
Whole-group debrief 3	3	2	3	3	2
Small group 4	3	3	3	4	3
Whole-group debrief 4	3	2	2	2	2

Observer reflections

Either the roles Ms. French put in place or the mathematics content was more familiar to the students. Either way, the small-group discussion was much more effective in this lesson. Students seemed clearer about what was required in the problems, and they had productive discussions.

Feedback

Ms. French shared her aspirations for the future and her eagerness to participate as a mentor in next year's Region 10 math collaborative as a mentor. She shared that she felt very knowledgeable and capable of implementing any strategies I suggested. My suggestions focused on identifying the student zone of proximal development and to use richer problems for student exploration and discussion. We discussed how to identify students' prior knowledge through pre-assessment in order to choose the scaffolds that might be needed for students to be capable of engaging in quality discussions of mathematical concepts. I also advised her about quickly moving students to a more rigorous level of mathematics and how discourse could facilitate that process.

Observation 3: April 2, 2015 / seventh period

General observations

Ms. French continued to try to encourage students to take responsibility for their learning and to improve the discourse in the small-group conversations. Students appeared to be responding to feedback by having discussions that seemed more productive each time.

Student discourse observations

The lesson Ms. French prepared consisted of a brief review of inequality concepts followed by three small-group discussions and two whole-group debrief discussions. In the final small-group discussion, students were instructed to complete three problems. This final segment was not followed by a discussion, but the papers were collected at the end of the lesson.

The first whole-group discussion review of inequality concepts was rated at lower levels on the Hufferd-Ackles et al. (2004) rubric than the subsequent whole-group decisions following the small-group discussions. It seemed that the students did not remember the concepts well enough to participate in the discussion. Ms. French lectured and interspersed some questions to keep students engaged. Still, some students were just guessing at the words and phrases she wanted:

Ms. French: That was the very basic part of how to graph a solution on a number line. What you are looking at in number two is a little bit different level. If we know that the colored-in circle means it has to be exactly five, what do you suppose the open circle would be? [Students are quiet.] What do you suppose that would mean?

Student 1: At the least?

Ms. French: He says at least five. What do you think?

Student 2: I don’t know.

Ms. French: Anyone else have an idea what the open circle might mean? If the closed circle means exactly that number, what do you suppose the open circle might mean? What do you think?

Student 3: More or less?

Ms. French: More or less. What do you think?

Student 4: That it’s close.

Ms. French: That it’s close to that number. What do you think?

Student 5: About?

Ms French: Good ideas! All good ideas. So if you look at number two, that’s where I want to start to make sure you develop a good understanding. Are you with me Max? It doesn't appear that way. Can you turn? If you'll sit correctly in your desk in a listening and learning position, then you'll be better prepared for your brain to learn. If you are laid out like at home, it's kind of hard to learn because you are in comfort mode. We need to be in our learning mode. Nicole charges $9 per hour for her babysitting services. She babysits to earn money for her class trip. She needs to earn more than $135 for the trip. So which solution best represents the number of hours Nicole needs to work to earn enough money for her trip? So, I've written up here what I know. We always need to make a "know" and "need to know" list. I know that she makes $9 per hour and I know that she needs more than $135. If I want to put something on a number line, if I want to graph a solution on a number line, I have to know what the solution is, then I have to solve it. So if I set up my equation, nine hours, I mean $9 per hour times a certain number of hours has to give me an amount greater than $135. I have told you about how my son works at Fast Chicken and he has been trying to save money for a computer. So I did the same thing for him at home. He's a senior and he doesn't like having a math teacher for a mom, because I make him do all his own math. He makes $8 and he wants to buy a computer, and he said, "Mom, it's going to take forever! How long do I have to work to be able to save up enough for a computer?" I said, "Well sit down and figure it out." He huffed and puffed and sat down and figured it out the same way Nicole would. If you make $9 per hour how long do you have to work to make more than $135? To solve the inequality, what does it mean to have the coefficient and the variable together?

Students: Multiply.

Ms. French: Multiply. So to get rid of multiplication the inverse operation is?

Students: Division.

Ms. French: Division. So if we divide both sides by nine we come up with 15. So I have to work more than 15 hours, exactly 15 hours is going to put me at $135, but I have to work more than 15 hours. Exactly 15 hours is going to put me at $135. But I have to work more than that. I can't work exactly because the problem said "more than." So that's why it is written as an inequality. I need hours that are greater than 15, more than 15 hours. So I would go to my boss and say, "I need to work more than 15 hours this week because I have to have money for my class trip." So now knowing that, look at your number line. H is everything greater than 15. Which one do you think looks like that? Greater than 15?

Students: Umm, F? F, yeah.

Ms. French: Initially you had H because you had a dot on 15 and everything greater. Then you said F because you have an open circle on 15 and everything greater. Which one do you think it is and why? Stacy, what do you think and why?

Stacy: H.

Ms. French: She says H. What do you think?

Students: H.

Ms. French: Bill, what do you think?

Students: H.

Ms. French: If this said "greater than or equal to," it would be H. Remember what we said over here? When we graphed the solution we said exactly five, we put a dot on the five, no doubt. In this case you have an inequality. When we have an inequality and we have an open circle. It says it's a protected number. You're protecting that number from everything else. So when you see the open circle, it's going to be everything greater than the number or less than that number. But it's not going to be equal. The closed dot is equals, greater than or equal to, less than or equal to. So that's the difference. The closed dot means that in some form it's going to be equal, but the open circle is a protective circle around it and it's going to be everything less than that number or greater than that number. Knowing that, which answer choice do you see that matches it?

Students: F.

Ms. French: It has to be F. F has the open circle on 15. We need more than 15, not exactly 15, we need more than 15 so that's why it has to be an open circle.

In contrast, the whole-group debrief discussions following the small-group discussions represented at least one level higher on the rubric for *questioning, explaining mathematical thinking,* and *sources of mathematical ideas* and two levels higher for *responsibility for learning,* as seen in Table 45.

Ms. French: So Ben, what did your group talk about on number six?

Ben: Okay, so we knew Keisha and her friends would be four and it says they split $6.50 and we multiplied $6.50 times four and then we got F. I mean H, not F.

Ms. French: Why did you choose H?

Ben: 'Cause it was exactly.

Ms. French: So anywhere in the problem did it ask you for greater than or equal to, less than or equal to?

Ben: It said equals the total. Equals.

Ms. French: They split it equally and they asked you the total cost. So if each person spends $6.50 and there's four people, you multiply and that's

$26. So you had to go find $26. So should that be a closed dot or open?

Students: Open, closed.

Ms. French: Closed. Remember exact means closed.

The small-group discussions, which were formatted similarly to the prior week, were rated higher than the whole-group debriefs. *Questioning, sources of mathematical ideas,* and *responsibility for learning* were scored at the highest level. *Explaining mathematical thinking* was scored slightly lower level because all the students were not consistently engaged completely in the discussions. While Ms. French circulated in an attempt to keep students on task, there were interruptions and some administrative tasks that demanded her attention. (Weighted scores can be seen in Figure 17.)

Table 45

Ms. French's April 2, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
1:24	1:27	3		Reminders, passing/ collecting papers	NA	NA	NA	NA
1:27	1:31	4		Directions	NA	NA	NA	NA
1:31	1:38	7	19.44%	Review inequalities	2	2	2	1
1:38	1:44	6	16.67%	Small group 1	4	3	4	4
1:44	1:47	3	8.33%	Debrief 1	2	2	2	2
1:47	1:51	4	11.11%	Small group 2	4	3	4	4
1:51	1:56	5	13.89%	Debrief 2	2	3	3	3
1:56	2:07	11	30.56%	Small group 3	4	3	4	4
2:07	2:06	1		Turning in packets	NA	NA	NA	NA

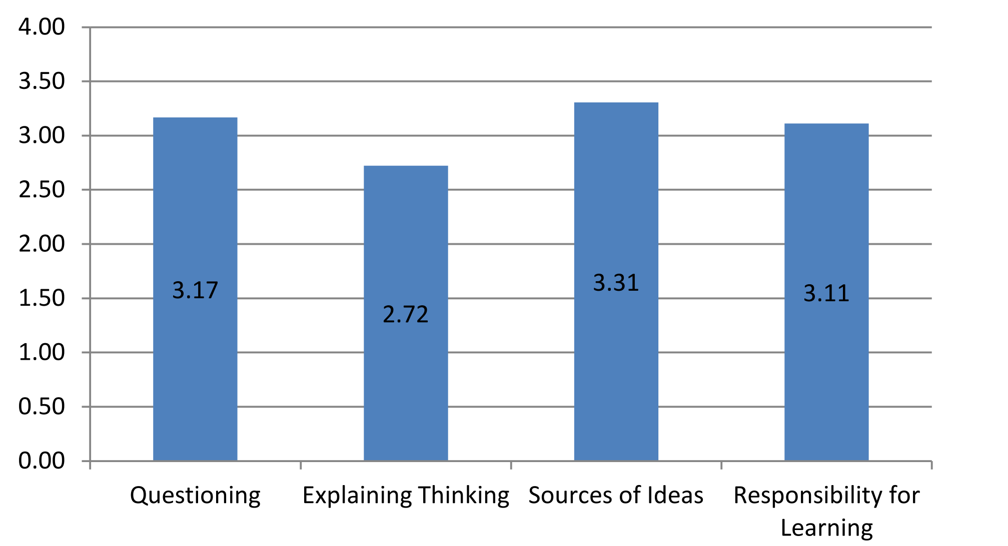

Figure 17. Ms. French's April 2, 2015 Math Talk Community weighted scores.

When considering the Marshall (2013) instructional factors, the whole-group review was scored at Level 2, except *order of instruction*, which was scored at Level 1 for several reasons: it was a review of concepts, the students were struggling to participate, and the activity used to explore the concepts with which the students were struggling ended once an answer was achieved. In contrast, the whole-group debriefs following the small-group discussions were rated at Levels 2 and 3, as seen in Table 46. These increases represented Ms. French asking students to share their solutions and strategies rather than guiding them through the solution:

Ms. French: Ben, tell me again why your group chose H.

Ben: Because Keisha and her friends equals four and they split it equally. Then we multiplied $6.50 by four and we got 26.

Ms. French: And why was it closed dot that you chose?

Ben: Because it wasn't greater or less than.

Ms. French: Very good. Anyone else have different way to explain that? How about your group? What did you talk about?

Lance: Like it's like the same thing.

Ms. French: The same thing? Did everyone choose H?

Students: Yes

Sarah: No, I.

Ms. French: That's okay. What were you thinking when you chose I?

Sarah: We got a different number.

Ms. French: Let me see. Where did that come from? [Points to the multiplication work on her paper.]

Sarah: We multiplied by six then 50.

Ms. French: Oh, I see. So did you multiply it as decimal? ‘Cause we know if we multiply it like a decimal, it is very different than like a whole number.

She probed or repeated at times, but the students generally provided the explanations for much of the second whole-group debrief session.

Reasons for not scoring these whole-group discussions at the highest level were in part due to the application level of the questions, rather than the higher concept development level. Some groups of students were disengaged during the student presentations and did not appear to listen to other students’ assertions. As demonstrated in the second whole-group debrief, Ms. French had to ask again and again for students to share ideas, but most did not connect to other students’ solutions.

Table 46

Ms. French's April 2, 2015 Instructional Factors

Student Actions	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Reminders, passing/collecting papers	NA	NA	NA	NA	NA
Directions	NA	NA	NA	NA	NA
Review inequalities	2	1	2	2	2
Small group 1	3	3	4	3	3
Debrief 1	2	3	2	2	3
Small group 2	3	3	3	2	3
Debrief 2	3	3	3	3	3
Small group 3	3	3	4	3	3
Turning in packets	NA	NA	NA	NA	NA

The Marshall (2013) discourse factors appeared more consistent than the other rubrics. The whole-group review was scored across all factors at Level 2 because the questioning ended up being at a low level, and there was limited student contribution. *Questioning level*, *complexity of questions*, and *questioning ecology* for all remaining segments were scored at Levels 2 and 3, as stated in Table 47. The kinds of problems the students were investigating and the request to just provide their solution and explain it but with little interaction from other students in the discussion meant that Level 4 was not attained, as demonstrated in the following small-group discussion:

Shannon: The temperature dropped 11 degrees in the last hour. The temperature is currently below 50 degrees Fahrenheit. Which of the following could be used to determine the temperature, T, one hour ago? Now we know our informational is that our temperature is…

Beau: It dropped 11 degrees.

Shannon: Yeah but it started at 50.

Beau: T.

Shannon: So we have to find an equation that represents 50 minus 30 equals T.

Beau: And we know the temperature is below 50 degrees Fahrenheit. So our question is to determine an equation that represents T an hour ago.

Mike: So we got to subtract.

Shannon: Then it will get bigger.

Mike: No, 50 take away 11 is less.

For similar reasons and because some students were not participating fully, *communication pattern* for the whole-group debriefs was scored at Level 2. However, during the small-group discussions, *communication pattern* was scored at Level 4 because of the engagement of students in the small-group conversations.

Table 47

Ms. French's April 2, 2015 Discourse Factors

Student Actions	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
Reminders, passing/collecting papers	NA	NA	NA	NA	NA
Directions	NA	NA	NA	NA	NA
Review inequalities	2	2	2	2	2
Small group 1	3	3	3	4	3
Debrief 1	3	3	2	2	3
Small group 2	3	3	3	4	3
Debrief 2	3	3	2	2	3
Small group 3	3	3	3	4	3
Turning in packets	NA	NA	NA	NA	NA

Observer reflections

Perhaps the whole-group review would have been a bit more successful if there had been pre-assessment to determine students' prior level of knowledge. However, most students in the small-group discussions seemed to be taking responsibility for their learning and were beginning to hold each other accountable for participation and explaining their responses.

Observation 4: April 16, 2015 / seventh period

General observations

The final lesson observed had five segments. The first segment consisted of calling roll. In the second and fourth segments, Ms. French gave directions for the upcoming activity and gave students advice for the upcoming assessment and how to be good students. During the third segment, Ms. French conducted a discussion reviewing order of operations. In this segment, there was didactic questioning with closed and open questions to guide students through the steps required, for example, “What comes next?” and “Now what?”. There were also some instances where the questions were open-ended, asking students “How would I check it?” and “Does anyone know why?”. The most open-ended questioning occurred during the review segment when Ms. French prompted students, “Tell me what you know about parentheses.”

The second discussion segment focused on questions from a packet on personal financial literacy (PFL). In this segment, Ms. French employed the “Tell me what you know” technique, a three-minute partner talk, and asked students to explain their thinking by instructing them to “Tell me why.” The students seemed excited during this segment, volunteered information, and asked pertinent questions of Ms. French.

Student discourse observations

During both discussion segments, Ms. French attempted to engage students in a very open discussion. While the teacher attempted to probe for more complete answers to her open questions, she was not always successful in getting students to actually discuss the topics. In the following excerpt, Ms. French wanted to review order of operations with students. She used the following problem to guide her review:

$$\frac{7 + \left(3^3 - 2\frac{1}{4}\right) \times 3}{2^3 \times 1}$$

Ms. French: On the surface, you look at it and think, "How am I going to solve that?" Step one is, you have to remember your steps. Raise your hand and tell me what the steps are in solving a problem like this. What are the steps?

Student: Uh, parentheses first?

Ms. French: Parentheses first? Then what comes next?

Student: Uh, exponents?

Ms. French: Then what?

Student: Multiplication…or division.

Ms. French: From left to right, then what?

Student: Addition or subtraction, left to right.

Ms. French: Yes, left to right. If you know this piece, you're a long way ahead of most people.

At this point Ms. French began a lecture format to explain computations. In the remaining portion of the segment, Ms. French continued to ask "Now what?" and "What comes next?" as she guided the computations to finish out the problem. When completing the final division portion of the problem, Ms. French guided the students step-by-step through the algorithm. She did all the work, but paused to ask students “how many groups of eight go into” the next value to be considered. She was focused on completing the work through modeling and didactic questioning, and she was the only one to offer explanations.

She was able to facilitate a much more conversational discussion of PFL during the second discussion segment when the students were excitedly offering information about their personal experiences with banking and credit reports. She began the segment by reviewing a problem in which the subject, Leila, was considering a variety of banking choices. Ms. French guided the students through the options offered by four banks and Leila’s typical banking practices. This portion included more open questioning like, “Explain how important this is.” Next, Ms. French asked the students to talk at their tables about their prior knowledge on credit and debit cards. Following this brief, animated student-to-student discussion, Ms. French initiated a lively conversation about credit and debit cards. Students interjected questions and Ms. French allowed the conversation to extend to credit reports and the importance of building a good credit score:

Ms. French: Now when you do things like that, it builds your credit. One thing it talks about here is your credit worthiness, your credit report. If you have good credit, then it is more likely that a bank will lend you the money to buy a house or buy a car. If your credit report or your credit score is low, they think, “Hmm we can’t trust them, we are not going to give it to them.” But if your credit is high, Bill may come in with an 800 credit score and he says I have $20,000 to put down on a house and they say, "Yes sir, sign here." But if you come in with a 200 on your credit score and you have that money, they say, "Well I am glad you have that money but take it somewhere else because we can't trust you." So credit, as you become an adult, is a very big thing. Credit worthiness is a very important part. That's why you have to be very careful with these credit cards. Are there any questions?

Student: [Raises hand.]

Ms. French: Yes ma'am.

Student: I never knew why your credit score mattered, ever, 'cause I've seen all these commercials to get your credit score on TV.

Ms. French: Like Credit Karma.com where you can go and get your actual credit report for free. There are three different agencies and you can go and give them your social security number and they can tell you what your credit score is at all times. Your parents can do it and we can all do it. You guys don't have credit yet because you are not quite old enough. But as you get older, once you are 18 you can apply for credit cards and start developing that credit. (Audio recording, 2015)

Ms. French continued to extend the conversation to include an example using one of her students. This resulted in scores of Level 4 in *questioning* and *sources of* *mathematical ideas* and Level 3 for *explaining mathematical thinking* and *responsibility for learning*, as shown in Table 48. (Weighted scores can be seen in Figure 18.)

Table 48

Ms. French's April16, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
1:23	1:24	1		Calling roll	NA	NA	NA	NA
1:24	1:28	4		Directions	NA	NA	NA	NA
1:28	1:42	14	36.84%	Order-of-operations whole-group review	3	2	2	2
1:42	1:46	4		Directions	NA	NA	NA	NA
1:46	2:10	24	63.16%	PFL problem whole-group review and discussion	4	3	4	3

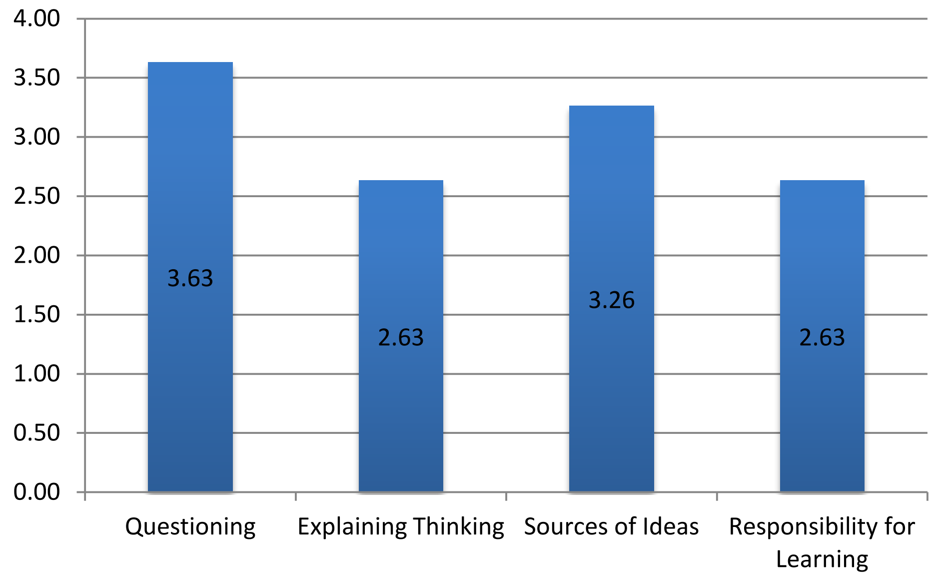

Figure 18. Ms. French's April 16, 2015 Math Talk Community weighted scores.

Using the Marshall (2013) instructional factors rubric, the first discussion segment was scored at Level 3 across all factors. While the students were asked open-ended questions, evidence of strong conceptual understanding was missing. Students had either previously explored concepts (because it was a review) or discussed with a partner prior to whole-group discussion, but the teacher was required to prompt students along in the discussion. The teacher frequently acted as facilitator, and the students were generally active learners. The concept discussions were at an application level for the most part. In contrast, the second discussion segment was scored at Level 4 for all factors except *order of instruction,* which was scored at Level 3 because while Ms. French did ask students what they knew, she did not really provide an activity for students to explore and understand the financial concepts. The other instructional factors were rated at Level 4 because of the student interest and full engagement in the discussion. (See Table 49 for instructional factors.)

Table 49

Ms. French's April 16, 2015 Instructional Factors

Student Actions	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Calling roll	NA	NA	NA	NA	NA
Directions	NA	NA	NA	NA	NA
Order-of-operations whole-group review	2	2	2	3	3
Directions	NA	NA	NA	NA	NA
PFL problem whole-group review and discussion	4	3	4	4	4

The variation in the discussions was more evident when applying Marshall (2013) discourse factors rubric. For both segments, *questioning level* challenged students at a variety of levels from basic recall to analysis level—Level 4. Again, for both discussion segments, *complexity of questions* was scored at Level 3 because students were challenged to explain or reason but did not critique others' responses. However *question ecology* and *communication pattern* were scored only at Level 2 for the order-of-operations review discussion segment, but were scored at Level 4 for the PFL discussion segment. The increase from one segment to the other was directly related to the students' eagerness to volunteer information and ideas about debit cards and commercials they had seen on television. Students even shared, "I didn't know why it was important” and “So if we never get a credit card, we never get credit?”. As the conversation continued to a problem regarding a checkbook register, Ms. French briefly explained what a checkbook register was, and the students explained the missing entries in the register. At this point, Ms. French diverged into a personal story about her son (about to graduate and start college) considering his options for financing his college expenses. The whole-group discussion became a student-guided conversation:

> Students: [Talk excitedly.]
>
> Student: Where is UTA?
>
> Ms. French: The University of Texas at Arlington is in Arlington. They are paying him a certain amount of money to come there just because he has good grades. He didn’t have to do anything except put forth the effort to have good grades.
>
> Students: [Talk excitedly.]
>
> Ms. French: A scholarship he doesn’t have to pay back, but a loan for the rest of it, he will have to pay that back.
>
> Student: So where is UTA?
>
> Ms. French and other students: Arlington
>
> Student: When I go into Wal-Mart with my momma, and she gets into the checkout line, she wants to use her card, she has to call and check her balance.

Ms. French: Well you see that's the new age, we don't see people use checks anymore. When they are unsure and want to know their balance they go to the app and see what my balance or call and ask, "What's the balance on my card?", but if we kept up, like we did originally like with these [points to the check register displayed on the board], then we know at all times. But people stopped doing that when debit cards came along. Yes.

Student: So, if we don't never get credit cards, then we don't ever get credit?

Ms. French: Well, it's good to, credit cards are good for that purpose to build credit. But there are other things to build credit too. If you are disciplined and not go, "Whoo I've got $500 to spend" and go and spend it real quick, because then all you have to do is spend the next 12 months trying to pay it back. So what my son does, he's got a debit card that he treats it like a credit card. He has a pre-paid credit card that I've gotten for him. So I've put a certain amount on it so he can just go blow it. He has to account for it and so he goes and gets gas, he brings me the receipt, then he pays me back and I go and put the money back on the card. So I getting him disciplined and that this is not free money. So you can use it but you have to pay it back and he understands how that works. So you can use other things to build your credit. Yes.

Student: So we got a debit card and a credit card. When y'all get a debit card do you have to remember that number?

Ms. French: You'll have to remember your PIN number. When you set up your bank account they will say, "Do you want a debit card?" and you will say, "Yes" because you want to go to the ATM and you want to pay your bills. They will give you a four-digit code and you have to remember that code.

Student: My mom told me hers.

Students: [Talk excitedly.]

The prior excerpt provides an example of the highest levels of discourse ecology. Perhaps it was because of the financial context being discussed, the personal context Ms. French added, or the connection to student's future financial choices. (See Table 50 for discourse factors.)

Table 50

Ms. French's April 16, 2015 Discourse Factors

Student Actions	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
Calling roll	NA	NA	NA	NA	NA
Directions	NA	NA	NA	NA	NA
Order-of-operations whole-group review	4	3	3	2	2
Directions	NA	NA	NA	NA	NA
PFL problem whole-group review and discussion	4	3	4	4	4

Observer reflections

Ms. French spent less time lecturing at students and more time prompting students for information. She was more successful during this lesson as she seemed to be asking questions at appropriate levels, scaffolding as needed. Overall, it was a much more engaging discussion involving a large number of her students. Perhaps the PFL topic was more engaging—perhaps this is an example of why teachers need to provide pertinent context for mathematical discussions.

Feedback

I shared brief feedback with Ms. French during the break in the discussion to pass out packets for the second discussion segment:

Coach: Thank you for doing the little encouragement for the kids.

Ms. French: Of course.

Coach: It sounds like a small thing, but not everybody does it.

Coach: [Hands Ms. French her certificate for participating in the follow-up coaching intervention.]

Ms. French: [Takes a few minutes to make sure students have their packets.] I really like the, uh, the online part that you had us do. I really liked that a lot and the one on STAAR prep. I have been teaching nine years and it was really an eye opener. The videos were great to see it in action. They were modeling it and it really gave me something to think about.

Ms. French and I went on to discuss some logistics of the last session. I shared how engaged I thought the students were in the discussion, how they seemed to sense the relevance to their lives. At the end of the math portion of her class, Ms. French shared news of her own. Her administrator informed her that her contract would not be renewed at the campus for next year. We spent a few minutes talking about districts that might be a better match for her teaching style, which she described as "out of the box." Ms. French also volunteered how helpful the online resources were to her.

Summary of Student Discourse Observations Over Time

At the beginning of the intervention, Ms. French was already using some strategies to encourage students talking. She had implemented some student-to-student segments in her classroom, along with long periods of lecture. After the feedback I provided, she found that if her students were engaged for longer periods of time in mathematical conversations, the weighted scores on the Math Talk Community rubric would increase. In the second lesson I observed, she added a record-solve-repeat structure to the small-group conversations in which the first student recorded the “known” and “need to know” for the problem, the second student solved the problem, and the third student described how the group came up with the solution. I noted that after the first such small-group discussion, in which the students spent a good bit of time arguing over roles, the students were much more engaged in the discussions and on task than in the first lesson observed. In the whole-group discussions that followed the small-group discussions, I also noted that Ms. French held students accountable for their small-group work by asking them to report out to the whole class what they had done and what they were thinking. As seen in Table 51, Ms. French’s weighted scores for Math Talk Community were generally one level higher. While I did not hear Ms. French direct the students to use the same structure in the small-group discussions in the third lesson, the same high level of student engagement and discussion was noted. During the final lesson, Ms. French was reteaching some concepts (order of operations and PFL), which meant that she did more of the explanation than the students. However, either she or the topics were engaging because the students began participating fully in the whole-group conversations to the point that the students were asking Ms. French questions about the topic and she was responding, which had not been observed in any prior lessons.

Table 51

Ms. French's Math Talk Community Scores Over Time

	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
03/19/15	2.29	2.26	2.54	2.29
03/25/15	3.28	2.53	3.03	3.13
04/02/15	3.17	2.72	3.31	3.11
04/16/15	3.63	2.63	3.26	2.63

In addition to the Table 51, Figure 19 shows the increase in all dimensions of Math Talk Community—especially from the first to the second observation. As the intervention continued, Ms. French continued to maintain the initial increase in Math Talk Community over her first lesson and really began to reach the highest levels of *questioning*.

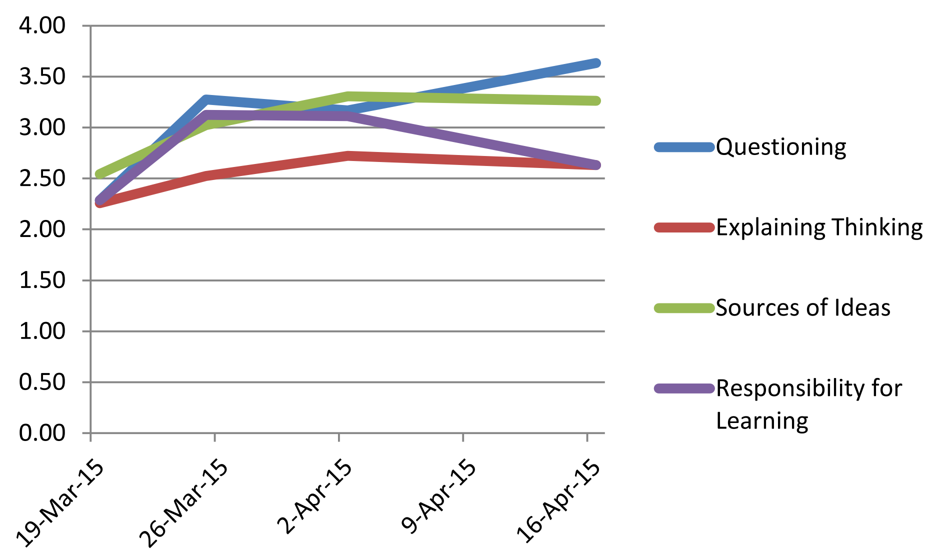

Figure 19. Ms. French's Math Talk Community weighted scores over time.

The scores for Marshall's (2013) instructional factors showed variability over the intervention, but ended about the same or higher than the first lesson observed. These factors specifically address the structures Ms. French put in place to support student engagement in mathematical discourse for learning the desired concepts. From the beginning, Ms. French was using some student talk strategies, but as the intervention progressed, Ms. French made the biggest gains in *instructional strategies* (as seen in Table 52 and Figure 20). During the first observation, Ms. French talked or lectured for longer periods of time with little or no student input. By the last whole-group discussion observed, the students guided the direction of the conversation with their questions and comments. This resulted in a very different whole-group discussion—one in which the students guided according to their interests and need for information. The level of student engagement was very high.

Table 52

Ms. French's Instructional Factors Over Time

	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
03/19/15	2.00	2.00	3.29	3.29	3.00
03/25/15	2.95	3.00	3.13	3.08	2.80
04/02/15	2.72	2.61	1.97	2.61	2.81
04/16/15	3.26	2.63	3.26	3.63	3.63

It should also be noted that *student role* and *knowledge acquisition*, while relatively high in the initial observation, were rated at the highest levels for large parts of the final observation. It seemed that as Ms. French tried strategies and began to get students familiar with how to participate in small-group discussions, and therefore levels of discourse increased.

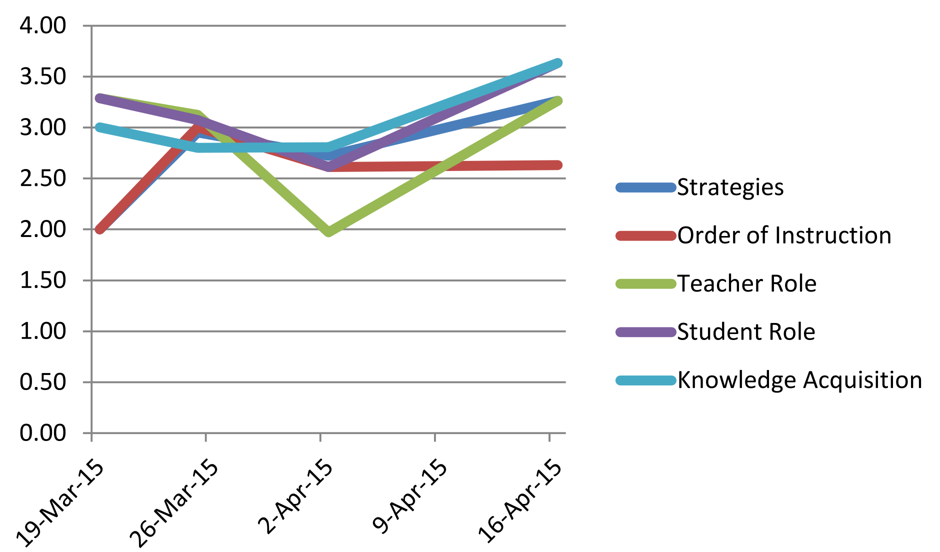

Figure 20. Ms. French's instructional factor weighted scores over time.

Of all the Marshall (2013) discourse ecology factors, the greatest change was seen in the discourse factors. Ms. French had relatively strong *questioning ecology* in the first observed lesson, but showed some variation in scores in later lessons when she attempted to cover large amounts of vital information during the 40-minute class periods. The last lesson observed turned out to be her last opportunity for instruction before the state test the following week; however, she did not seem rushed that day. *Complexity of questions* seemed to decrease over the intervention. In the first observed lesson, she seemed to be above the students' abilities to understand and engage in the concepts. While she was asking open-ended questions, the students appeared unable to answer them. Because of their inability to answer the questions, Ms. French launched into long periods of lecture. Her *questioning level*, however, increased in conjunction with the *knowledge acquisition* instructional factor and was directly related to the types of problems being worked. As Ms. French had the students answer more rigorous questions, discourse ecology factors increased.

Table 53

Ms. French's Discourse Factors Over Time

	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
03/19/15	3.00	3.29	3.29	2.29	2.29
03/25/15	2.80	2.60	2.85	3.18	2.60
04/02/15	2.81	2.81	2.58	3.17	2.81
04/16/15	4.00	3.00	3.63	3.63	3.26

The largest increases were seen in *communication pattern* and *classroom interactions*. As shown in Table 53 and Figure 21, by the end of the intervention Ms. French was able to engage her students in much deeper student-directed and productive mathematical conversations. The higher scores were from the increase in productive small-group conversation and the students' extended participation in whole-group discussions. This appeared to be the result of Ms. French setting up structure for small-group discussions and holding students accountable for their work by having them share their thinking with the whole class. By the final observed lesson a month later, the students appeared comfortable in their new roles and confident in sharing information after small-group discussions and asking questions of Ms. French.

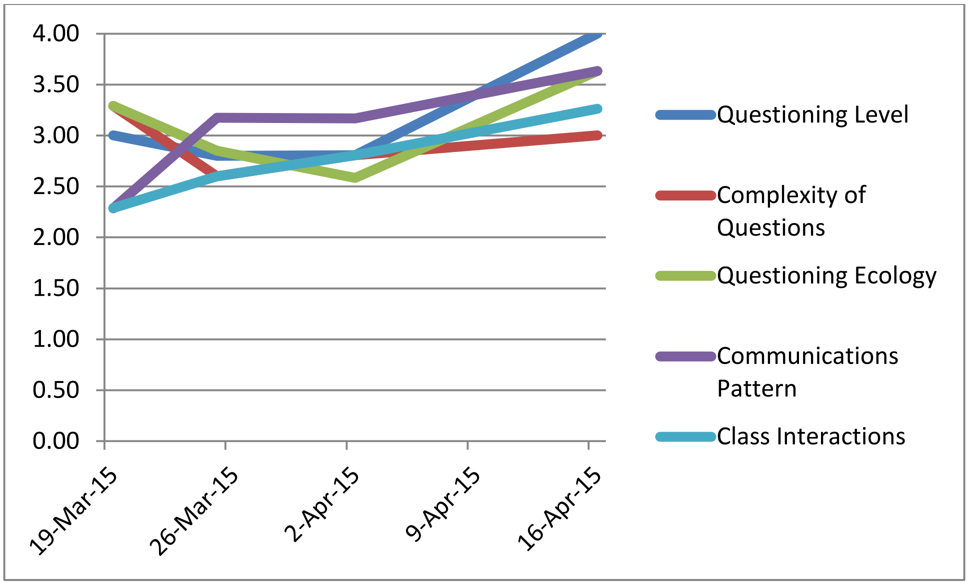

Figure 21. Ms. French's discourse factor weighted scores over time.

Post-Intervention Perceptions and Beliefs

Ms. French responded to the post-intervention reflection questions on April 16, 2015. In her responses she shared an enhanced understanding of discourse. She shared her new focus on student communication and its relationship to academic success. She shared that her students were talking more and that she changed her questioning strategies, as well as the structure for classwork. She expressed that her idea of experiences as important for students were the personal connections to content, as well as the other students and the teacher in the class. Her ideas remained unchanged about her role in the classroom and what it meant to do mathematics. She also shared that she felt the intervention was helpful because “Bianca helped pull things out of me that I already had, but was not using!”.

Conclusions About Changes in Beliefs and Instructional Practices

Of the teachers I worked with, Ms. French was the most eager to try new strategies and participated fully in the intervention activities, as well as the online *Student Talk = Math Success* course. She was a knowledgeable and capable teacher prior to the intervention. In spite of her strengths, she engaged in professional learning and discussions and strived to improve her craft to increase student performance. She recalled concepts from prior professional learning about student discourse and questioning, but admitted that she was not using these techniques in her instruction prior to the intervention. Perhaps because of the feedback provided or the online learning she participated in concurrent with the intervention, she seemed dedicated to making a change in her classroom instruction and succeeded in increasing discourse ecology. She also expressed growth in her understanding of the importance of student discourse in learning mathematics. This could also be related to the concurrent participation in the online course or the responses she was receiving from students in their increased ownership of their learning and the discussions in the classroom. Although Ms. French was an experienced and confident mathematics teacher, she demonstrated a change in her beliefs in addition to growing the levels of Math Talk Community in her classroom instruction.

The Case of Mr. Waters

Background

Mr. Waters is a first-year African-American male teacher in his late 20s. He had additional duties in the district as an assistant football coach. Mr. Waters is an alternatively certified teacher without a math or science undergraduate degree. The campus mathematics coach worked closely with him to provide him resources for instruction, and she stated that he was a natural teacher and was very open to suggestions. Mr. Waters' prior experience with student discourse is also limited, as he did not recall specific information related to how students talking about mathematics helped them learn mathematical concepts. The Blitz block I observed Mr. Waters teach had 25 students: 22 African-American students (15 boys and seven girls) and three Latino students (two girls and one boy).

Individual Lesson Observations, Discussion, and Scoring

Observation 1: March 25, 2015 / STAAR Blitz block C

General observations

Mr. Waters conducted his Blitz class similar to Mr. Kaye. Half the students faced the back of a very long, narrow classroom with laptops, and half faced the board and worked with Mr. Waters in a whole-group discussion. Mr. Waters had the students switch places about halfway through the block of time. There was an assistant teacher who monitored the laptop students, but offered them little assistance.

Mr. Waters' classroom management was good, and students felt comfortable asking him questions, sharing insights, and asking each other questions. I did not observe Mr. Waters specifically setting up the structure for this to occur, but it seemed to happen naturally as a result of the observed climate of respect he appeared to have cultivated in the classroom. There may have been a few students who were not completely engaged in the first discussion group, but he addressed that by redirecting and calling on students for participation.

Student discourse observations

Mr. Waters' class was divided into five separate segments, three of which were coded as not applicable for discourse analysis, including students entering and getting set up for learning, transitioning between whole-group and individual work on computers, and the final transition and clean-up segments. There were two segments in which the entire group of students was divided between whole-group review of previously attempted problems and working individually on computers. The discourse in the first question review session differed slightly from the discourse in the second session. This seemed to be in part because the students guided the discussion and because the two different groups of students had different questions and concerns.

In both question review segments, Mr. Waters asked the students about which of the independent practice problems from the prior Monday they had questions. The first group identified problems 2, 3, and 4. The second group identified 1, 2, and 4. In addition to the invitation to let students guide the content of the session, I identified four separate patterns of discourse during the two whole-group segments. The first pattern was a series of questions and prompts that guided the students through the problem with open-ended questions, to which the responses guided the rest of the discussion. For example, in the first question review segment, the teacher asked the students, “What’s my question?”. A student responded with, “Which equation best represents...”, reading from the stem of the problem. The teacher further prompted the students by directing them to the problem and suggested they look for hints. A student suggested, “x represents the cost of items per.” The teacher repeated the student’s statement and then explained where to find that information. A student volunteered what “y represented.” The teacher prompted students for more information found in the problem statement by asking, “What else?”. Student responses in this pattern were typically explanations and descriptions of their strategies.

The second pattern, which seemed to dominate the segments, was more about students conducting an error analysis of their work. Students were asked and freely described their thought processes on the problem and, as needed, the teacher explained the mathematics or test-taking strategies. For example, students offered, “I know this said two; I just didn’t pay attention,” “Sometimes I missed the problem when I changed into a mixed number,” and “How I did it, I added up everything in my head. It was the sum of those numbers. I had did it in my head.”

The third and fourth patterns of communication occurred only in the second question review segment when students offered other strategies for solving the problems, which evolved into students asking other students to clarify their strategies. This segment included student statements and questions like, “I want to say something about the second one. I saw the improper fraction to mixed number…”, which after some questioning, the teacher understood the misconception and explained a method for changing an improper fraction into a mixed number. Then a student asked, “So she said...” and began to restate in her own words what she thought the student had stated and continued with “So you can…” while moving up to the board to demonstrate a shortcut she used to convert improper fractions to mixed numbers.

I used the Hufferd-Ackles et al. (2004) rubric to assess the levels of Math Talk Community. In the first segment, Mr. Waters’ *questioning* helped students focus on their thinking rather than just on the answers (Level 2), but in the second segment students spontaneously began to question each other (Level 3), an effort Mr. Waters supported:

Mr. Waters: Yes, Melanie.

Melanie: Sometimes I set up the division problem as a fraction, and then I write it down as division.

Mr. Waters: Good job! Yes sometimes it’s hard to remember how to set up the division problem, so she says she sets it up as a fraction to remember to take the top and divide it by the bottom.

Sam: When you take the top and divide it, you mean you add the zeros?

Mr. Waters: You add the zeros. That’s exactly what I mean. Yes.

Stewart: Uh, I think this is what she said. I’m just trying to see. She said that it’s already in a fraction; she just divides it?

Students: No.

Mr. Waters: No, in order to remember how to set up the division problem, she puts the numbers in a fraction, so she can know what goes inside and what goes out. Very, very important that you know, that you do it right, which one goes inside and which one goes outside.

Sandra: Like if it was two and the division sign and eight, then it is two over eight?

Ms. Waters: Exactly.

Sandra: [Goes to the board and demonstrates how to write the division problem correctly.]

The levels of Math Talk Community in the question review segments were scored similarly for *explaining mathematical thinking* and *sources of mathematical ideas* (Level 3), as shown in Table 54. In both segments, the teacher was focused on student thinking about the problems, and students frequently volunteered their strategies and errors in thinking. Their second question review segment also generated a higher score than the first in the level of *responsibility for learning*. In the first segment, the teacher was beginning to set up the structures for listening to each other by having students share their thought process (Level 2). In the second segment, some students were responding to others' ideas and asking them questions (Level 3), as seen in the previous excerpt. The results are displayed in Figure 22.

Table 54

Mr. Waters' March 25, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
9:58	10:00	2		Organizing students into two groups	NA	NA	NA	NA
10:00	10:27	27	47%	Group A—whole-group question review Group B—computers	2	3	3	2
10:27	10:29	2		Transition	NA	NA	NA	NA
10:29	11:00	31	53%	Group B—whole-group question review Group A—computers	3	3	3	3
11:00	11:00	1		Transition and clean-up	NA	NA	NA	NA

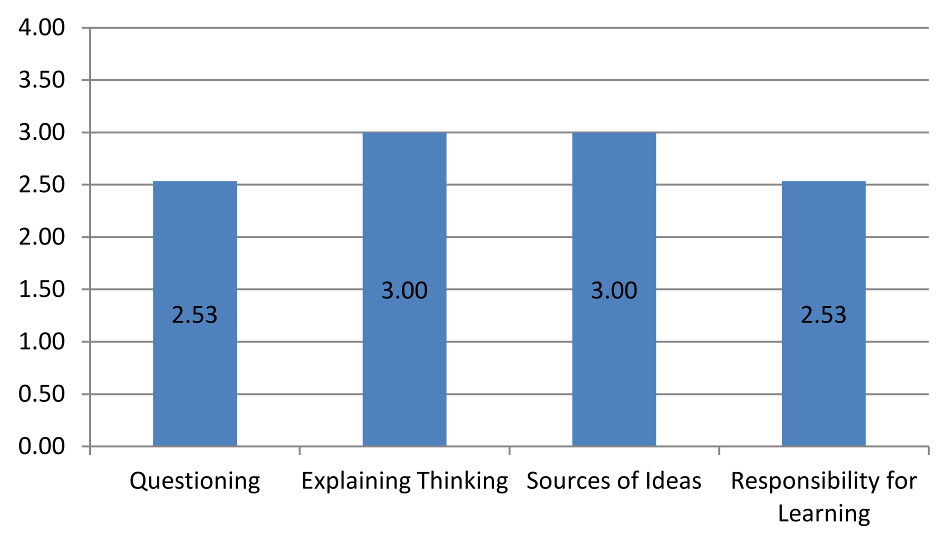

Figure 22. Mr. Waters' March 25, 2015 Math Talk Community weighted scores.

The Marshall (2013) instructional factors for both question review segments showed almost identical results: *instructional strategy, order of instruction, teacher role,* and *student role* all at Level 3 and *knowledge acquisition* at Level 2. While the teacher occasionally lectured, he acted more as a facilitator for the segment, resulting in a Level 2 score. This was even more evident in the second whole-group discussion segment, which earned a Level 3 for *teacher role*. The students were active learners, and the teacher only provided explanations as needed after the students shared their strategies and questions. *Knowledge acquisition* was scored lower at Level 3 simply because the students were attempting to solve application problems for the most part. (See Table 55 for instructional factors.)

Table 55

Mr. Waters' March 25, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Organizing students into two groups	NA	NA	NA	NA	NA
Group A—whole-group question review Group B—computers	3	3	2	3	2
Transition	NA	NA	NA	NA	NA
Group B—whole-group question review Group A—computers	3	3	3	3	2
Transition and clean-up	NA	NA	NA	NA	NA

The Marshall (2013) discourse factors for both segments were scored at Level 3, with the exception of *questioning ecology* for the first question review segment, which was scored at Level 2.

The patterns of communication challenged students in both segments, demonstrating Mr. Waters' persistence in helping students analyze problems to understand a good approach to solving them:

Mr. Waters: We've got to find what?

Students: The equation.

Mr. Waters: Now what that tells us is that we are looking for an equation, is that in the problem somewhere they should have given us a hint to what's going to be in this equation. So what are some of the hints? Yes.

Hilary: It says a flat rate of $6.50 for shipping.

Mr. Waters: Good job! A flat rate of $6.50 for shipping, so we know that $6.50 will be in our equation someplace. What else?

Sally: x represents the cost of the items purchased.

Mr. Waters: x represents the cost of the items purchased. We are going off an Internet business. So we know that x represents the cost of something we purchased on the Internet. What else?

Susie: y represents the total cost with shipping

Mr. Waters: y represents the total cost with shipping, total cost, the total cost with shipping. And we know what shipping was right? x represents the cost of what we purchased but y represents the total cost of what we purchased.

Billy: So you, uh, you already owe $6.50 with shipping, then you gonna have to add $6.50 shipping and add it on to the original cost.

Mr. Waters: You are going to add the cost of what you bought to the shipping.

In the first question review segment, the teacher attempted to have students explore their strategies and reasoning, but he was more successful in the second segment when students began to discuss each other's ideas, as described in the first excerpt. In both segments, the discussion was not only guided by student questions, but also focused on the questions the students had about the independent practice. With Mr. Waters' facilitation, students were allowed to analyze their thinking and errors. Students volunteered their thinking and their misunderstandings:

Mr. Waters: Yes, sir.

Bobby: First I added this, then I had done the wrong thing. So I looked at this up here.

Mr. Waters: You looked at the chart?

Bobby: Yeah.

Mr. Waters: When you look at the chart, Ashley, tell me what is changing between x and y? What is going on?

Ashley: What I did was to find what was changing, I took y, $7.50, $7.50 and subtracted it from uh, $1 and then I got $6.50. And then I kept going.

Mr. Waters: Did you get \$6.50 when you did y minus x, did you get \$6.50 each time?

Ashley: Yeah.

Mr. Waters: You did? So it was a consistent \$6.50 that was being added to x, it was consistent \$6.50. Yes, what did you do?

Tom: To make sure I was right, I had went back and I took \$6.50 and added it to all the xs to see if I got the y.

Mr. Waters: You tested it. You tested your theory and went back and you added. You took x and said, okay I am going to add \$6.50 this time and see if I get the answer over here, and I do. I do.

Also, throughout the two segments students were asked to share and justify their reasoning on these previously attempted problems. Mr. Waters encouraged student sharing with his positive reinforcement:

Mr. Waters: Carol.

Carol: The only reason I got this one correct 'cause in the commercial when it say, "plus shipping and handling."

Mr. Waters: That's actually a very good example. That's exactly what they do. They add it. They say plus shipping and handling. They don't say multiply shipping and handling. That's a good example. Yes.

Sam: At first I had picked G but I wasn't sure. But I knew they were adding on so that I knew it was F.

Mr. Waters: Man, high five! [Gives a high five to Sam.]

In this way, Mr. Waters was able to encourage students to reflect on their errors and share them with their classmates. (See Table 56 for discourse factors.)

Table 56

Mr. Waters' March 25, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Organizing students into two groups	NA	NA	NA	NA	NA
Group A—whole-group question review Group B—computers	3	3	2	3	3
Transition	NA	NA	NA	NA	NA
Group B—whole-group question review Group A—computers	3	3	3	3	3
Transition and clean-up	NA	NA	NA	NA	NA

Observer reflections

Mr. Waters demonstrated great instinct when it came to conducting and generating rich mathematical discussions. While his classroom management abilities were not mature, they were sufficient and perhaps allowed more freedom for students to participate in the learning. Mr. Waters' questioning style and insistence that students provide explanations and justifications for their solutions increased the discourse ecology in his classroom. It also resulted in greater student participation in the discussion and perhaps greater understanding of the mathematical concepts.

Feedback

I provided initial feedback to Mr. Waters briefly after the lesson as we walked together to the PLC session immediately following. I verified that he was indeed a first-year teacher and shared how impressed I was with his ability to conduct a rich discussion—specifically how he allowed students to have voice in which problems were discussed. In addition, I used some of the discussion in his classroom as examples in explaining the rubric and student discourse during the PLC discussion. I shared how his students began to share their problem solutions. He interjected that he was relieved that the scene I described was positive, as he was not himself too sure about it. I assured him that students sharing their solutions and misconceptions were exactly what we needed them to do.

In the PLC discussion, Mr. Waters expressed gratitude to see the relatively high rubric scores of the conversation in his classroom. He expressed concerns that the lesson might have been negatively perceived because of all the questions the students were asking. I pointed out on the rubric where such discussions would be scored and assured him he was on the right track.

Observation 2: April 2, 2015 / STAAR Blitz block C

General observations

Mr. Waters conducted his lesson very similarly to the prior week. However, this week only two students were assigned to the computers, and the whole-group discussion included all the remaining students, resulting in a group almost double in size. In addition, the discussion lasted almost the entire block, which was double the amount of time. It seemed that because Mr. Waters did not have the students rotate, there was extra time at the end for students to demonstrate their understanding with two additional independent practice problems.

Student discourse observations

There were two segments in the lesson where the discourse rubrics were deemed applicable: (1) students circulating and checking answers and inquiring about strategies with each other and (2) whole-group review of the problems. The segment in which the students circulated yielded rich discussions among the students, possibly because of the set-up Mr. Waters provided. His directions were to find a partner and "compare your answers and strategies with your partner's answers and strategies, see what they did that you didn't do or what you did that they didn't do." Another possible reason for this strategy's success was the observed openness and respect demonstrated for student ideas. Students seemed comfortable sharing and asking questions of each other.

As mentioned earlier, while the whole-group format was the same, it included most of the class and lasted almost the entire 60-minute block. During the whole-group discussion, there were extended periods of didactic prompting for answers and reasoning. I also noted six times when Mr. Waters probed students for their reasoning, but once provided, the conversation moved to the next step. There were two occasions when students shared personal analyses of their errors or volunteered their misconception. Consequently, in using the Hufferd-Ackles et al. (2004) rubric, the whole-group discussion was scored lower than the previous week at Level 3 for all aspects (*questioning, explaining mathematical thinking,* and *sources of mathematical ideas*), with the exception of *responsibility for learning*.

Mr. Waters: Does anyone have any questions about this one? Why we solved or why we put what? Ms. Alexander.

Ms. Alexander: I thought we were supposed to multiply because a positive six, when it's a number next to an x that means we are supposed to multiply. That's why I thought we were supposed to multiply.

Mr. Waters: Did you put $6x$ or did you put x plus six?

Ms. Alexander: $6x$.

Mr. Waters: $6x$ is multiplication. That is what I was referring to earlier. If you put $6x$, that is multiplication. Now, the inverse operation of multiplication is?

Students: Division.

Mr. Waters: Then you would have had to be divided by six. But this wasn't supposed to be $6x$; it was x plus six. It was an addition. They were adding x to the positive six. What we weren't doing was multiplying six different xs. [Draws the model for x on the board six times.] Does that make sense?

Ms. Alexander: Yeah.

This excerpt is an example of students learning from their mistakes and sharing with the group—and Mr. Waters utilizing it as a learning opportunity. *Responsibility for* *learning* was scored at a Level 2 because while Mr. Waters began to set up structures for students to listen to each other, he provided most of the feedback on their input:

Mr. Waters: Why F and H?

Adrian: J, because, it wasn't…

Mr. Waters: Help him out. Why is J not the right answer?

Elvis: Uh, we already knew that number should get smaller.

Mr. Waters: That's right. [Goes on to explain why J would not be correct.]

However, the segment in which students circulated and discussed their answers and strategies were all scored at Level 4 on the rubric. This was due in large part to how Mr. Waters set up the discussion and how the students conducted themselves. I did not observe Mr. Waters facilitating any of the discussions as he did the independent practice. This might have resulted in even richer discussions. (See Table 57 and Figure 23 for Math Talk Community scores.)

Table 57

Mr. Waters' April 2, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
10:00	10:03	3		Administrative and organizational tasks	NA	NA	NA	NA
10:03	10:12	9	16%	Students circulating to discuss solutions and strategies	4	4	4	4
10:12	10:50	48	84%	Whole-group discussion	3	3	3	2
10:50	10:54	4		Turning in papers. getting papers	NA	NA	NA	NA
10:54	11L01	7		Working independently on new problems	NA	NA	NA	NA

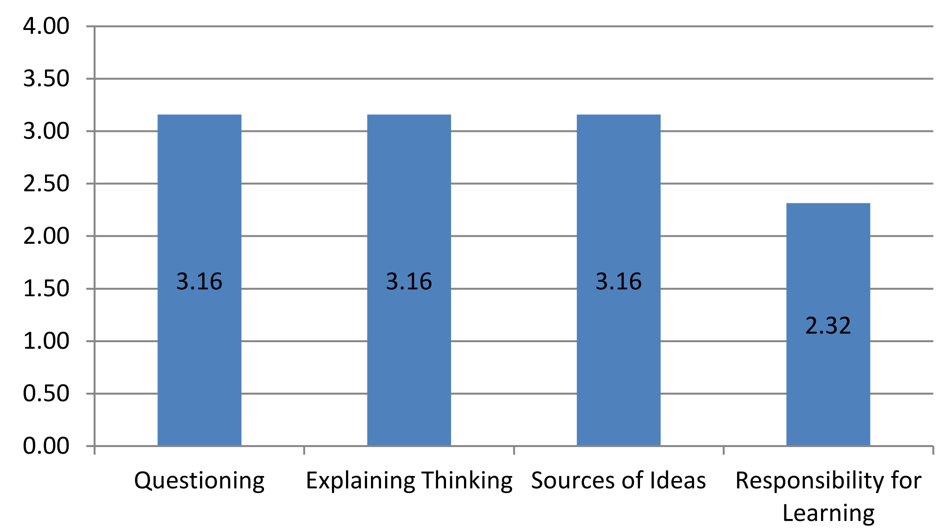

Figure 23. Mr. Waters' April 2, 2015 Math Talk Community weighted scores.

Using the Marshall (2013) rubric, there was a bit more differentiation in the segment scorings. In the student circulating segment, the instructional factors were at Level 4 for *instructional strategies*, *order of instruction*, and *teacher role*. The students may not have been consistently engaged, resulting in a Level 3. Likewise, the students did not consistently press each other for justifications, and the problems being used resulted in a *knowledge acquisition* score of Level 3. (See Table 58 for instructional factors.)

Student: I don't understand what it is.

Mr. Waters: This is a balance scale. Points to the double-pan balance model in the problem.] What does the scale represent? Melanie.

Melanie: It uh, the equation.

Mr. Waters: An equation. So an equation has what, Melanie?

Melanie: Uh, an equal sign.

Mr. Waters: An equal sign. So we know when we see a balance, the middle is an equal sign. The fact that both of these are even on the scale should tell us that one side is the same as the other side or equivalent to the other side. So we pull out the equal sign from the scale. Now, what is on the left of the scale? Somebody raise your hand and tell me. Ms. Reynaldo.

Ms. Reynaldo: Negative seven.

Mr. Waters: Negative seven because they have seven little balls over here. Negative seven. Now what is on the right of the scale?

Student:	Positive six.
Mr. Waters:	It's a positive six on the right of the scale. What else is on the right of the scale?
Student 2:	x.
Mr. Waters:	Melanie?
Melanie:	x.
Mr. Waters:	x. Now Melanie, should that be positive $6x$?
Melanie:	No, it should be x plus positive six.
Mr. Waters:	It should be x plus positive six. It should not be $6x$. $6x$ would not look like six positives and one x. $6x$ would look like six different x shapes. [Draws six x shapes on the board.] (Audio recording, 2015)

In this excerpt, Mr. Waters attempted to develop mathematical reasoning related to a balance pan model of an equation.

Table 58

Mr. Waters' April 2, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Administrative and organizational tasks	NA	NA	NA	NA	NA
Students circulating to discuss solutions and strategies	3	4	4	3	3
Whole-group discussion	3	4	3	3	3
Turning in papers, getting papers	NA	NA	NA	NA	NA
Working independently on new problems	NA	NA	NA	NA	NA

The discourse factors also varied from Levels 3 to 4 in the student circulating segment. It was scored at Level 3 for *questioning level, complexity of questions, questioning ecology*, and *classroom interaction* for the same reasons—Mr. Waters did not circulate to encourage students to press for justifications and the level of the problems being discussed. Many students simply told each other the answer they had and what they did to get it. However, the segment was scored at Level 4 for *communication pattern*, as students were required to explain their strategies and reasoning, the teacher was completely uninvolved, and students were managing their own discussions:

Mr. Waters: Read number five for me Henry.

Henry: Sawyer and his brother evenly split the cost of dinner. The total cost of the dinner was $15. Based on the model below, what is x, the amount Sawyer paid for dinner?

Mr. Waters: What's my question, Eddy?

Eddy: Based on the model what is x, the amount each brother paid?

Mr. Waters: So based on the model. What are the important things that will help me solve this problem? Kelly?

Kelly: Total cost for the dinner was $15.

Mr. Waters: Total cost for the dinner was $15. What else would help me, Kenny? What else is important in this problem? [Waits.] What is$x$?

Kenny: The amount.

Mr. Waters: The amount each paid for dinner. What is x, the amount Sawyer paid for dinner? What else is very important in this problem, Melanie?

Melanie: Oh…

Mr. Waters: [Waits.] Help her out Ms. Alexander.

Ms. Alexander: Um, you need to underline "evenly split the cost."

Students: Ohhh.

Mr. Waters: Now what did I say every time you have a model?

Students: Write it out, you have to write out what you see!

Mr. Waters: You need to write out what you see in the model, a numeric expression or equation. So, they gave us a model to tell us the equation. What does the model tell me? [Waits.] Let's say on the left. What does the left side tell me?

Student:	Positive 15.
Mr. Waters:	Positive 15! What else is in the model Cara?
Cara:	$2x$.
Mr. Waters:	$2x$. Is it two plus x?
Students:	NO!
Mr. Waters:	Or is it multiplied by x. What goes in the middle?
Students:	Equals.
Student:	Inverse operation!
Mr. Waters:	What do I need to do now? Kelly?
Kelly:	Divide.
Mr. Waters:	Why do I need to divide? [Waits.] Why do I need to divide? Why do I need to divide? Ms. Alexander?
Ms. Alexander:	Because you multiply and you need to do the inverse operation.
Mr. Waters:	It's multiplied by x but I need to get x by itself. So that's why I need to divide. [Continues in this manner to complete the problem.]

In this excerpt, Mr. Waters prompted students to analyze the problem and determine how to solve it. Attempts to elicit reasoning seemed lacking compared to the prior observation, perhaps because he was working with the larger group. (See Table 59 for discourse factors.)

Table 59

Mr. Waters' April 2, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Administrative and organizational tasks	NA	NA	NA	NA	NA
Students circulating to discuss solutions and strategies	3	3	3	4	3
Whole-group discussion	3	3	2	2	3
Turning in papers, getting papers	NA	NA	NA	NA	NA
Working independently on new problems	NA	NA	NA	NA	NA

The whole-group segment was scored at Levels 2 and 3 for the majority of the Marshall (2013) factors. Only *order of instruction* was scored at Level 4. Although there were two occasions in which Mr. Waters successfully facilitated students sharing reasoning, the discussion was very controlled. Additionally, the majority of the questioning was focused on receiving brief, single responses.

Observer reflections

There was definitely a difference in Mr. Waters' energy level, and perhaps the students sensed it as well, which is why I glimpsed opportunities missed by Mr. Waters to really engage students in rich discussions.

Feedback

Mr. Waters seemed distracted and a bit stressed. When I asked him how everything was going, he alluded to some discipline problems and how it was affecting the students and work. I did not probe more deeply to find out details about the problem, but rather asked other campus teachers later. They reported that students had become increasingly rowdy at school, which had resulted in discipline issues and several student suspensions. Additional feedback was provided to Mr. Waters via e-mail and in the PLC feedback session. The e-mail feedback focused on Mr. Waters' role when students were discussing among themselves, similar to the first student-to-student discussion segment. While it may have been tempting to get administrative tasks done at that time, it can mean that the opportunity set up for rich discussion was not capitalized upon by the students without teacher facilitation.

Observation 3: April 7, 2015 / STAAR Blitz block C

General observations

This was a different day of STAAR Blitz, and the format of the lesson was different from prior observations because all students were working through the lesson and there were no students on laptops. The purpose of the day was for students to review concepts and complete independent practice problems. Mr. Waters' class began with passing back papers and students working silently on the bell-ringer problem. Mr. Waters then conducted a whole-class review of the bell-ringer problem. He then went through four additional problems, some of which he had students discuss in twos or threes prior to whole-group discussion. He also reviewed the benchmark fraction/decimal/percent conversions briefly with full-page laminated flashcards. The last segments of the class were 20 minutes of independent practice and then collecting papers.

Student discourse observations

Several different discourse patterns were identifiable during the 35 minutes of alternating whole-group and partner discussions. The most basic pattern was occasional periods in which the teacher asked for simple, single responses, wrote them on the board, and continued. Mr. Waters asked students for their solutions and explained it or shared an additional strategy. The periods in which the teacher asked students to discuss with their partners, while brief, resulted in students explaining to each other their mathematical ideas. During the whole-group discussion, there were significant periods of wait time noted before Mr. Waters finally provided a hint or suggested a strategy.

Scoring of the whole-group discussion segments yielded ratings of Level 2 in *questioning* and *responsibility for learning* and Level 3 for *explaining mathematical thinking* and *sources of mathematical ideas*.

Mr. Waters: Now that we have them all as percentages, which subject has the highest passing rate? Andre?

Andre: Umm...

Mr. Waters: The highest passing rate?

Andre: Science.

Mr. Waters: He said science. Science had the highest passing rate. Which subject had the lowest passing rate, Judy?

Judy: History.

Mr. Waters: She said history had the lowest. Now, Jonathan, did they want us to go greatest to least or least to greatest?

Jonathan: Least to greatest.

Mr. Waters: Least to greatest. So history should be first. Which one had history first, right?

Students: Yes.

Mr. Waters: So which one had history first?

Students: B.

Mr. Waters: B. We only had to find one!

During the two partner discussions, *questioning* was scored at Level 4, and *explaining mathematical thinking* and *sources of mathematical ideas* were scored at Level 3. Because the sessions were relatively brief, there was little opportunity for students to delve deeply into each other's thinking. Mr. Waters was beginning to facilitate structures for student discussions—Level 2 on *responsibility for learning*. Unfortunately, while the students were to discuss their ideas, Mr. Waters did not implement any accountability. Therefore, the sense of responsibility was perhaps less than if he had asked them to share their solutions. The segment in which Mr. Waters quickly reviewed the benchmark fractions and encouraged students to memorize them was scored at Level 1 because of only providing brief explanations. Table 60 displays the Math Talk Community levels for each of the categories; the weighted totals are displayed in Figure 24.

Table 60

Mr. Waters' April 7, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
9:57	9:59	2		Passing back papers	NA	NA	NA	NA
9:59	10:04	5		Student working silently on bell ringers	NA	NA	NA	NA
10:04	10:09	5	14.29%	Whole-group bell-ringer review	2	3	2	2
10:09	10:12	3	8.57%	Discussions with partners	4	3	3	2
10:12	10:20	8	22.86%	Whole-group discussion 2, 3	2	3	3	2
10:20	10:21	1	2.86%	Discussions with partners	4	3	3	2
10:21	10:30	9	25.71%	Whole-group discussion 4	2	3	3	2
10:30	10:35	5	14.29%	Whole-group benchmark fraction flashcards	1	2	1	1
10:35	10:39	4	11.43%	Whole-group discussion 5	2	3	3	2
10:39	10:59	20		Independent practice	NA	NA	NA	NA
10:59	11:00	1		Passing up packets	NA	NA	NA	NA

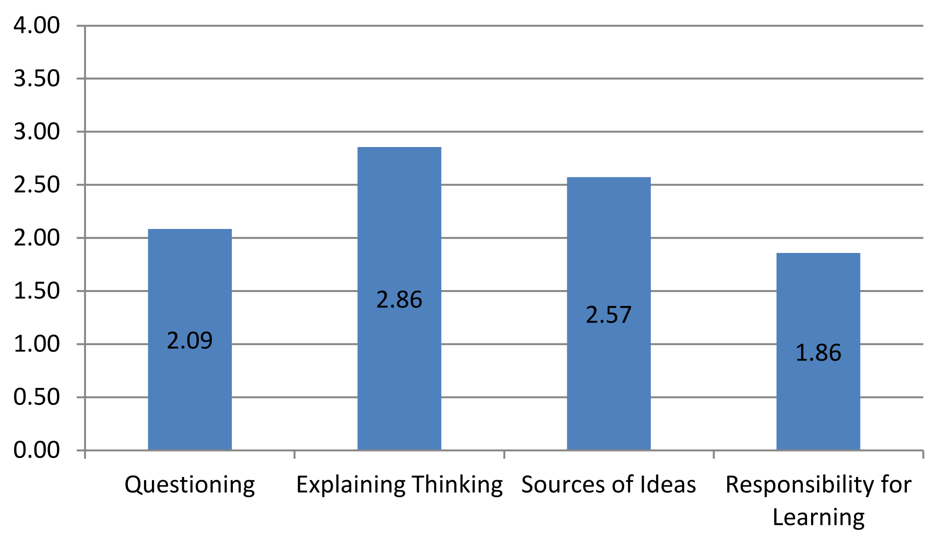

Figure 24. Mr. Waters' April 7, 2015 Math Talk Community weighted scores.

The complex patterns of discourse Mr. Waters facilitated in his classroom resulted in scores on all levels of Marshall's (2013) instructional factors and discourse factors—with discourse factors being slightly higher. The lowest scores were for the segment in which the benchmark fractions were reviewed. This required quick, recall-type responses from students, and few explanations or justifications were asked for or provided.

Using the Marshall (2013) instructional factors rubric, all whole-group problem reviews were scored Level 2 for *teacher role, student role,* and *knowledge acquisition*. However, *instructional strategies* and *order of instruction* were scored at Level 3 because students explored the problem first, and both the teacher and students explained their thinking. The score for *knowledge acquisition* was Level 3 because of the type of questions the students were exploring:

Mr. Waters: Somebody raise your hand and tell me how you guys came up with solving this problem.

Dave: We turned the mixed numbers into improper fractions.

Mr. Waters: You turned the mixed numbers into improper fractions. Okay, who else had a different way to solve the problem?

Ms. Alexander: Uh, we did it based on the whole number and the numerator and denominator.

Mr. Waters: You did it based on the whole number and the numerator and denominator. Because all of these were mixed numbers, you could have turned them into improper fractions and compared them, or you could have kept them as mixed numbers because they are all alike numbers and based on the whole numbers you might have been able to figure out the order of them. Did anyone have anything different?

Kelly: You turn them into a decimal.

Mr. Waters: You could have turned them all into a decimal. Good. So you did it at 3.25 instead of mixed numbers. Anybody else did anything different? [No response from the students; begins asking students which numbers were the greatest and least and then considers the answer choices.]

The review of benchmark fractions was scored Level 2 for instructional strategies and student role because questions were verification only and students were actively engaged for brief periods. The remaining instructional factors were scored at Level 1. During the two partner discussion segments, instructional strategies factor was scored at Level 4. The rest of the factors were scored at Level 3. Order of instruction, teacher role and student role were Level 3 because the students were not as effectively engaged as they could have been as the teacher was not circulating and encouraging richer discussion. Mr. Waters set up structures for students to work with each other.

> Mr. Waters: What do I do after that? What happens next? [Wait time] What do I need to find? [Wait time] What did you find, Danni?
>
> Danni: I did with uh, what he said.
>
> Mr. Waters: You did what he said? You turned them into fractions?
>
> Danni: Well I didn't do the fractions; we did decimals.
>
> Mr. Waters: Okay, so what did you do to find the second lowest fraction?
>
> Danni: Three and one-fourths.
>
> Mr. Waters: You said three and one-fourths was the second lowest fraction. So what did you convert that to as a decimal?
>
> Danni: 3.25.
>
> Mr. Waters: 3.25 and you said that was less than three and five-sixths and three and one-half?
>
> Danni: [Nods.]

Table 61

Mr. Waters' April 7, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Passing back papers	NA	NA	NA	NA	NA
Student working silently on bell ringers	NA	NA	NA	NA	NA
Whole-group bell-ringer review	3	3	2	2	2
Discussions with partners	4	3	3	3	3
Whole-group discussion 2, 3	3	3	2	2	3
Discussions with partners	4	3	3	4	3
Whole-group discussion 4	3	3	2	2	3
Whole-group benchmark fraction flashcards	3	1	1	2	1
Whole-group discussion 5	3	3	2	2	3
Independent practice	NA	NA	NA	NA	NA
Passing up packets	NA	NA	NA	NA	NA

The results from the Marshall (2013) discourse factors were similar, with the partner discussion segments scored highest on *complexity of questions* and *communication pattern* at Level 4. All whole-group segments (except the benchmark fraction review) were scored at Level 3 for *questioning level* due to the nature of the problems being discussed. Students were explaining their thinking:

Student: [Reads the problem.]

Mr. Waters: So what are they asking? [Waits.] Nathan?

Nathan: The fastest to the slowest times.

Mr. Waters: They asked us for the fastest to the slowest times. Correct. But what is that? What does that mean?

Nathan: Uh…

Katie: The time that is less than the others, because the time that is the lowest is the fastest time.

Mr. Waters: Say it loud, I can't hear you.

Katie: When you have the less number and you, um, the less number is the fastest.

Mr. Waters: So the least numbers are the fastest, not the larger numbers.

Katie: [Nods.]

Mr. Waters: So if we are going in order from least to greatest or greatest to least?

Katie: Um, least to greatest?

Mr. Waters: Least to greatest is correct.

In addition, students were sharing some error analysis (from an ordering integers problem):

Mr. Waters: What is the highest value I have?

Nathan: 24.

Mr. Waters: 24. That's the greatest value. So what is the least value in answer choice?

Beau: The first one?

Mr. Waters: Yep.

Beau: Ok, negative 11.

Mr. Waters: Negative 11. Why did you say negative 11?

Beau: Uh… I mean negative 13.

Mr. Waters: Why did you say negative 11?

Beau: Oh, ‘cause you said the first one.

Mr. Waters: I get you. What is the least? They don’t have it in order so you’ve got to put it in order. So if I ask you for the least was what?

Beau: Negative 13.

Mr. Waters: Negative 13. So the first one cannot be correct. Don’t get confused with the negative symbols. [Provides a brief explanation, using a number line, of the relative values of integers.]

The last whole-group segment discussion was scored a level lower on *complexity of questions* and *communication pattern*. As can be observed below, there was less of a discussion and more of a quick response to questions about the answers:

Mr. Waters: What does the question ask us to do?

Tyler: Put them in order from least to greatest.

Mr. Waters: It asks us to put them in order from least to greatest. But, do we have like numbers?

Students: No.

Mr. Waters: What do we have to do Melanie?

Melanie: We have to, uh, convert them to like numbers.

Mr. Waters: We've got to convert them. So how did you do that?

Jessica: We turned them into a percent.

Mr. Waters: You turned them into a percent? How did you do it?

Jessica: First I took the fractions and I divided the numerator and the denominator and got a decimal and then I turn that into a percent.

Mr. Waters: Okay so what was the decimal you got for these.

Jessica: Four-fifths, I got 0.8.

Mr. Waters: Four-fifths you got 0.8. [Writes the decimal values on the board as Jessica calls them out.]

Jessica: And then 17 over 20 I got 0.85.

Mr. Waters: 17 over 20 you got 0.85.

Jessica: And 21 over 25 I got 0.84.

Mr. Waters: You got 0.84. So she did hers by dividing the numerator by the denominator.

Classroom interactions and *questioning ecology* were scored at Level 3 for the whole-group segments (except the benchmark fraction review), while the partner discussions were scored at Level 4. The benchmark review segment was scored at Level 1 for *questioning level* and Level 2 across the rest of the discourse factors (Table 62).

Table 62

Mr. Waters' April 7, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Passing back papers	NA	NA	NA	NA	NA
Students working silently on bell ringers	NA	NA	NA	NA	NA
Whole-group bell-ringer review	2	3	2	3	2
Discussions with partners	3	4	3	4	4
Whole-group discussion 2, 3	3	3	3	3	3
Discussions with partners	3	4	3	4	4
Whole-group discussion 4	3	3	3	3	3
Whole-group benchmark fraction flashcards	1	2	2	1	2
Whole-group discussion 5	3	2	3	2	3
Independent practice	NA	NA	NA	NA	NA
Passing up packets	NA	NA	NA	NA	NA

Observer reflections

Mr. Waters continued to demonstrate a variety of strategies supporting student discourse. His students were engaged during all small-group discussions and for the most part during whole-group discussions. Several students appeared to feel comfortable expressing their mathematical ideas and misconceptions. These same students also voluntarily asked questions about other students' ideas and responses. I observed Mr.

Waters using wait time and open questioning from the strategies shared in the PLC discussions.

Observation 4: April 16, 2015 / STAAR Blitz block C

General observations

Mr. Waters began the block as in prior observed lessons by getting students settled and passing out papers within two minutes. Only one student had done well enough on the review assessment to be on the computer. The remaining students participated in the whole-class discussion and review over order-of-operations concepts. As with Mr. Kaye's class, the students could recall parentheses-exponents-multiply-divide-add-subtract (PEMDAS), but still struggled with applying the concepts to problems. Mr. Waters' class only had two segments: (1) the beginning segment where students were finding their seats and receiving papers back from Mr. Waters and (2) the whole-group discussion, which lasted the remaining 61 minutes of the block.

Student discourse observations

Mr. Waters facilitated a very student-centered discussion of the problems. In two different problems, one student presented his/her solution, but several students were eager to share their ideas to either add onto the solution presented or to correct it. In both instances, Mr. Waters revealed neither his agreement nor disagreement with the student suggestions, but simply asked if students had additional ideas with statements like, "You got something to say about that?". Many times several students raised their hands enthusiastically in an attempt to share their ideas:

Mr. Waters: Let’s go through some of these questions to see what we should have did, what we could have done to get more people on computers. Otto, read the problem please.

Otto: As Thomas was checking the homework he made a mistake when simplifying the expression. Below there are different ways of simplifying the expression. Which expression is equivalent to the simplified version of the original expression?

Mr. Waters: So we all know we are supposed to circle the question. But what else in the problem is important that we need to pull out? [Waits.]

Alexandra: The expression equivalent.

Mr. Waters: No. Something specific to the problem we need to pull out.

Sam: Mistake in simplifying the expression below.

Mr. Waters: Mistake in simplifying the expression below. Mistake. Mistake means we are looking for what Aja?

Aja: What is wrong?

Mr. Waters: We are looking for what is wrong in the simplifying process. So, based on that strategy, which is order of operations, tell me what are we supposed to do first?

Students: Parentheses.

Mr. Waters: What about parentheses? [Waits.]

John: Dividing.

Mr. Waters: So we need to divide because there is a division symbol in the parentheses. Kelly, you got something to say about that?

Kelly: That 0.8 to the second power.

Mr. Waters: What about it, 0.8 to the second power?

Kelly: It isn't supposed to be 16. It's supposed to be 64.

Mr. Waters: It's supposed to be 64? It's not eight. It is 0.8.

Kelly: No, it is supposed to be 0.64.

Mr. Waters: It's supposed to be 0.64, but why? Why Annie?

Annie: Because you have to do the exponent first like Kelly said. And if you have an exponent it is to the second power, which is eight times eight.

Mr. Waters: She said even though we are supposed to do parentheses first, Kelly was correct, but inside the parentheses we are not supposed to do the division, we are supposed to do the exponent. Even though it is inside the parentheses, we have to do inside the parentheses with order of operations. So, 0.8 multiplied by 0.8, should have given us what?

Students: 64.

Mr. Waters: Not 64.

Students: [More loudly] 0.64.

Mr. Waters: Yes, 0.64. But they put 0.16 divided by two. So this is the line with my mistake.

There were also a few instances when students did not wait to be prompted, but rather volunteered ideas, solution approaches, and even analysis of their own errors. In the following excerpt, the students and Mr. Waters worked through the steps in simplifying an expression using order of operations:

Mr. Waters:	25 minus seven is what?
Mike:	25 minus seven?
Mr. Waters:	25 minus seven.
Mike:	It will be 18.
Mr. Waters:	18 plus my positive 12 that I bring down is what?
Mike:	30.
Mr. Waters:	30. Based on the answer, I know that answers one and two are both equivalent to 30.
Student:	[Interrupts.] It's B.
Mr. Waters:	So what can I eliminate?
Students:	A and C.
Mr. Waters:	A and C because A and C neither have the second expressions equivalent to 30.
Jack:	So how is expression three equivalent to 30? 'Cause I just solved it, and I got 96.
Mr. Waters:	Okay. Let me help you out. This is one thing I want you to see.

Mr. Waters went on to suggest test-taking strategies for the upcoming state assessment. Because of this very student-centered approach to the lesson, the Hufferd-Ackles et al. (2004) Math Talk Community scores were all at the highest levels, with *sources of mathematical ideas* scored at Level 3 because while students were prompted to share their solutions, there could have been more prompting to share the mathematical ideas and justifications behind their ideas (Table 63 and Figure 25).

Table 63

Mr. Waters' April 16, 2015 Math Talk Community Scores

Start Time	Stop Time		Student Talk	Student Actions	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
9:58	10:00	2		Passing back papers	NA	NA	NA	NA
10:00	11:01	61	100%	Review of order-of-operations whole-group discussion	4	4	3	4

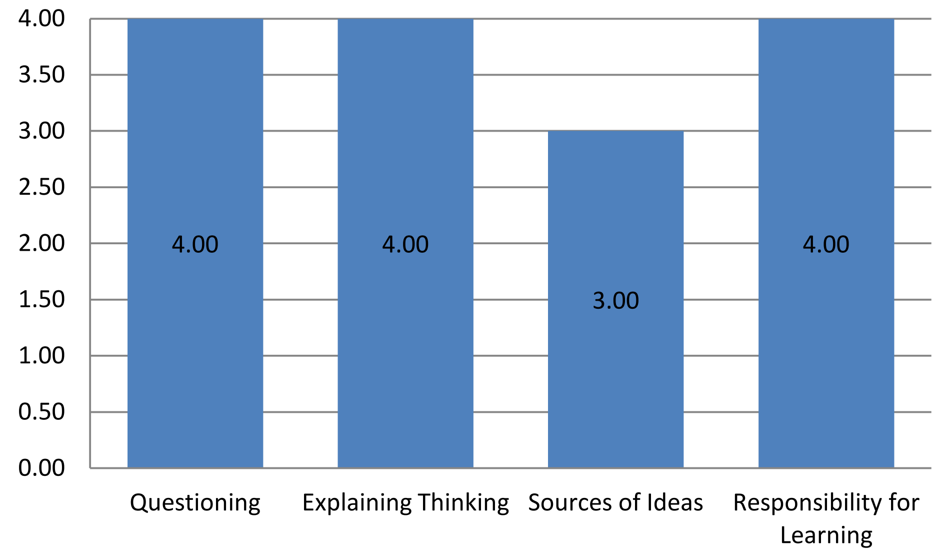

Figure 25. Mr. Waters' April 16, 2015 Math Talk Community weighted scores.

Table 64

Mr. Waters' April 16, 2015 Instructional Factors

Segment	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
Passing back papers	NA	NA	NA	NA	NA
Review of order of operations whole-group discussion	3	4	3	3	3

Table 65

Mr. Waters' April 16, 2015 Discourse Factors

Segment	Questioning Level	Question Complexity	Questioning Ecology	Communication Pattern	Classroom Interactions
Passing back papers	NA	NA	NA	NA	NA
Review of order of operations whole-group discussion	3	4	3	3	3

The Marshall (2013) instructional and discourse factors were scored generally at Level 3, with a couple scored at Level 2 and Level 4, as seen in Tables 64 and 65. *Classroom interactions* was scored at a Level 2 because the content was at a basic application level but also included analysis of the process and work others had done. *Instructional strategies* was scored Level 3 because there was no real inquiry focus—perhaps because this was a review session. *Teacher role* and *student role* were also scored at Level 3 because there were some lecture portions to the discussion, both about content and test-taking strategies. *Order of instruction* was scored at the highest level—Level 4—because the discussion came after students attempted the problems on their own, and Mr. Waters did not explain until after much discussion and suggestions by students:

Mr. Waters: Kay. Let me ask you a question, Kay. What do you want to do add to our problem?

Kay: Negative five plus 10.

Mr. Waters: You want to add negative five plus 10. So you want to go back to the previous line?

Students: No.

Kay: Negative four times 10.

Mr. Waters: You want to add negative four times 10.

Kay: Yes.

Mr. Waters: Go ahead, don't be shy. [Lets Kay go to the board and write down her ideas.] So. Thank you, Kay. So, Kay took 10 and multiplied it by negative four. Does anybody think they can add to our problem? Maybe to help us finish or what. Melanie?

Melanie: [Writes her ideas on the board while students raise their hands and exclaim.]

Mr. Waters: So she said negative 25 plus negative 40 is negative 65. So that's our answer.

Students: No. [Talk excitedly.]

Mr. Waters: Excuse me, hold on, hold on. Andrew, can you add to our problem?

Andrew: [Goes to the board and rewrites the last line.]

Mr. Waters: So you think that the answer at the end is incorrect. Okay. So what did you come up with?

Andrew: [Points to the board.]

Mr. Waters: So you came up with 15. So you said that negative 25 plus negative 40 is positive 15.

Andrew: [Adds a negative sign on the board.]

Mr. Waters: Oh so you said it is supposed to be a minus 15. Why?

Andrew: Because when you have two negatives you add.

Mr. Waters: Speak up. When you do what? Something up here had to give us two minus symbols. Something had to happen earlier. Can anybody help us or find it?

Complexity of questions was also scored at Level 2, as the questions and prompting seemed to be focused on the steps and the answers, not on their thinking:

Mr. Waters: What do I do first? Or what do I do second, whatever, what am I doing?

Students: [Raise hands eagerly.]

Beau: Multiply… I mean, uh, exponents.

Mr. Waters: We do exponents first. Why though?

Beau: Because we don't have parentheses.

Mr. Waters: Because we don't have parentheses. So the exponent is two to the third power. What does that mean?

Cabot: It means two times two times two.

Mr. Waters: It means two times two times two. I have two multiply by two, multiply by two. Which is what?

Students: Eight.

For similar reasons, *questioning ecology* and *communication pattern* were scored at Level 3. While Mr. Waters facilitated a very student-directed discussion with students interjecting solutions, they were not asked to justify their ideas by the teacher. *Questioning level* was scored at Level 4 because students were asked questions at a variety of levels, from recalling the words that go along with the order-of-operations acronym to error analysis.

Observer reflections

This was perhaps the most student-centered whole-group discussion in Mr. Waters' classroom that I observed. However, he fell short on helping his students reach a very rigorous and productive discussion by not requiring that students justify their answers. If this had occurred, I think more students would have had a greater understanding of the relatively confusing concept. In my opinion, Mr. Waters is well on his way to being an excellent facilitator of student discourse.

Summary of Student Discourse Observations Over Time

Mr. Waters responded to suggestions for increasing the discourse ecology in his classroom. Except for the third observation, the Math Talk Community levels in the observed levels increased over the intervention (Table 66 and Figure 26). In the first lesson observed, Mr. Waters worked with half the students and was able to facilitate an effective whole-group discussion with the dozen or so students in each segment, perhaps because the whole-group segments in the first observation included half as many students. In the later lessons, all or almost all of Mr. Waters' students were together for the whole-group segments, meaning almost double the students. During the third observation, Math Talk Community dropped because he was reviewing flashcards for fraction-to-decimal-to-percent conversions—which was a low-level memorization task. The reasoning and skills needed to perform the conversions were not part of the discussion.

Table 66

Mr. Waters' Math Talk Community Scores Over Time

	Questioning	Explaining Thinking	Sources of Ideas	Responsibility for Learning
03/25/2015	2.53	3.00	3.00	2.53
04/02/2015	3.16	3.16	3.16	2.32
04/07/2015	2.09	2.86	2.57	1.86
04/16/2015	4.00	4.00	3.00	4.00

Even with the increased numbers of students, Mr. Waters added quick student-to-student discourse strategies that were successful for brief periods of time in facilitating a Math Talk Community. The large increase in the last lesson observed was not because of small-group conversations, but because Mr. Waters persisted in requiring students to explain their thinking and analyze other students' suggestions for errors or to add onto what was already said. He also asked several times for alternate methods and strategies. This raised the level of Math Talk Community, even with the larger number of students, to the highest levels for almost all categories.

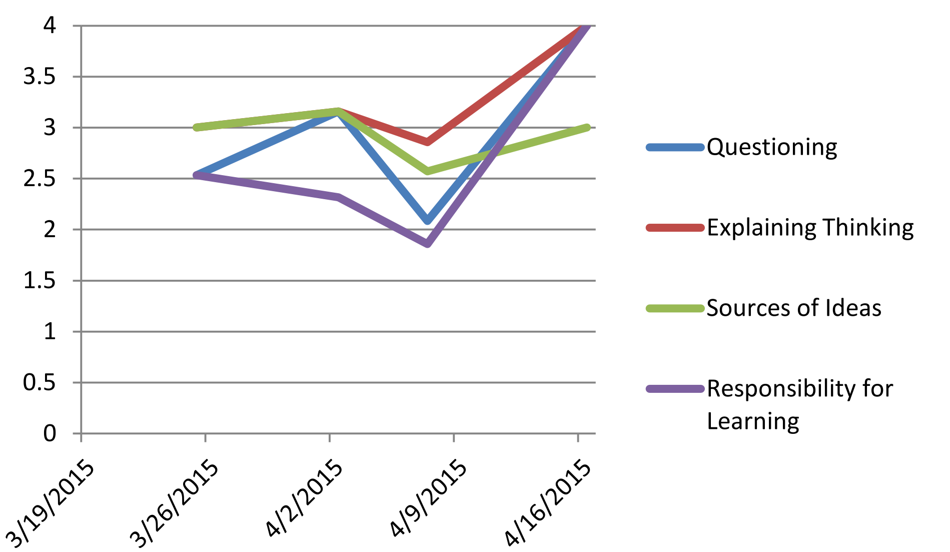

Figure 26. Mr. Waters' Math Talk Community weighted scores over time.

Similar patterns in the scoring can be seen in Mr. Waters' lessons, as instructional and discourse indicator scores dipped in the third lesson *for order of instruction, student role, knowledge acquisition, questioning level, complexity of questioning, communication pattern,* and *classroom interactions* (Tables 67 and 68).

Table 67

Mr. Waters' Instructional Factors Over Time

	Instructional Strategies	Order of Instruction	Teacher Role	Student Role	Knowledge Acquisition
03/25/2015	3.00	3.00	2.53	3.00	2.00
04/02/2015	3.00	4.00	3.16	3.00	3.00
04/07/2015	3.11	2.71	3.47	2.14	2.57
04/16/2015	3.00	4.00	3.00	3.00	3.00

Table 68

Mr. Waters' Discourse Factors Over Time

	Questioning Level	Complexity of Questions	Questioning Ecology	Communication Pattern	Classroom Interactions
03/25/2015	3.00	3.00	2.53	3.00	3.00
04/02/2015	3.00	3.00	2.16	2.32	3.00
04/07/2015	2.57	2.86	2.71	2.71	2.83
04/16/2015	3.00	4.00	3.00	3.00	3.00

When considering how Mr. Waters' instruction improved over time, his *order of instruction* was high and ended at the highest level because he required the students to attempt the problems before either he or other students provided an explanation. While this was not as well implemented in the third lesson because the students were reviewing memorization facts, the other lessons were consistently at higher levels.

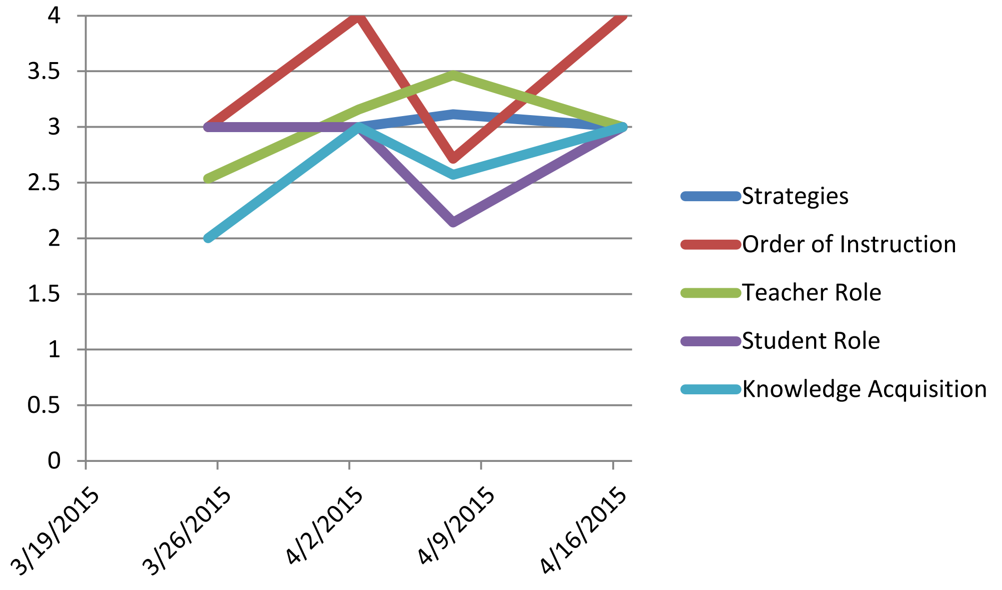

Figure 27. Mr. Waters' instructional factor weighted scores over time.

The growth in discourse factors over time was not as evident. However, Mr. Waters' lessons did show an increase in *complexity of questions*. When the intervention began, Mr. Waters asked students for input, but generally the responses provided were short phrases or single words—these were generally numerical answers or the next step in the process. He did have students read the problem and let them provide solutions, but he verified responses and communication was controlled. By the end of the intervention, Mr. Waters' lessons showed growth in his ability to engage students in thinking about and validating other students' solutions and reasoning. Several minutes were spent in error analysis of other students' work, and the entire class appeared eager to participate and share their thinking. (Weighted instructional and discourse factors can be seen in Figures 27 and 28, respectively.)

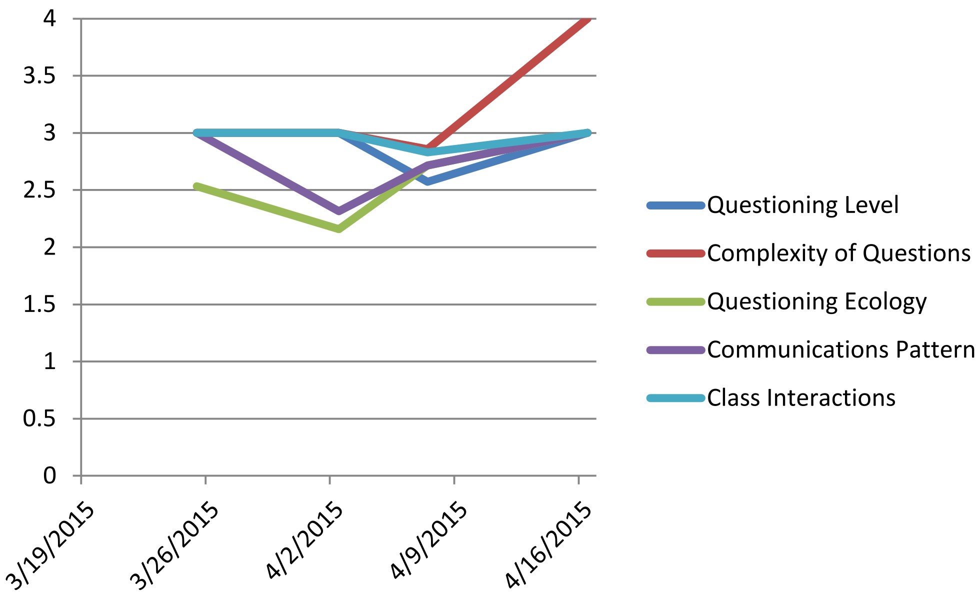

Figure 28. Mr. Waters' discourse factor weighted scores over time.

Post-Intervention Perceptions and Beliefs

Mr. Waters expressed his desire to increase student-to-student discussion. He implemented a version of the think-pair-share strategy (he had noticed some of his students felt more comfortable participating in discourse with peers than with the whole group). His goal in doing so was to have the students share and challenge each other's answers. He also hoped this method would encourage students to justify their answers.

Mr. Waters engaged in the PLC sessions by listening attentively, nodding when he agreed, and asking questions when he required clarification. During the March 25, 2015 PLC session, Mr. Waters expressed interest in and agreement with math talk moves shared. He demonstrated some of these moves in the April 7, 2015 lesson when he recorded what students were saying without validating and asked other students to add to the conversation. During the April 2, 2015 PLC, I suggested teachers try something different than telling students how to do problems correctly during the review. Instead, I suggested that perhaps the teachers needed to get the students talking, “prompting them to talk but not telling them too much”; at this point, Mr. Waters stated, “That’s what I’m having a hard time figuring out what to do.” In the next lesson I observed, he was successful in prompting students to share their ideas and multiple strategies. He helped them uncover misconceptions and addressed them during the lesson. In response to reflection questions after the intervention, Mr. Waters shared that student discourse allows students to recognize errors. He felt that the student-to-student and student-to-teacher communication provided a basis for teachers to fix incorrect thinking students have about mathematics concepts. These are actions I had observed Mr. Waters facilitate in his classroom.

Conclusions About Changes in Beliefs and Instruction

The intervention took place during the spring of Mr. Waters’ first year teaching. He had good instincts and he listened to students at the beginning of the intervention. He seemed to carefully consider the feedback I provided him during the intervention. He did not immediately implement all the strategies I provided, but appeared to consider which strategies fit with his style of instruction and met his students’ needs. While Mr. Waters had attended a face-to-face math talk training earlier in the year, he had not implemented any of the strategies. By the end of the intervention, Mr. Waters expressed value in letting students share their ideas and alternate strategies. His students rewarded his attempts by sharing their misconceptions and how the classroom discussion had helped them with error analysis and correcting long-held mistaken conclusions. While Mr. Waters appeared to be unsure of relinquishing control early in the intervention, the views he expressed post-intervention and the final lesson observed confirmed that he had indeed been convinced that student discourse was helpful for teachers to understand and dispel student misconceptions.

Analysis of PLC Sessions

March 25, 2015 PLC Feedback Session

Summary

On March 25, 2015 I met with three of the teachers participating in the coaching intervention: Ms. Anderson, Ms. French, and Mr. Waters. The session began with a review of our purpose —to increase student discourse in order to improve student understanding and performance on the upcoming math assessment (STAAR). I reviewed how I was doing the observations and audio recordings, as well as how I would be scoring the lesson using the Hufferd-Ackles et al. (2004) Math Talk Community rubric. I passed out a copy of the rubric descriptions to each of the teachers, and we discussed what each level looked like. During this discussion, I referenced specific events that had occurred in their classrooms as examples. About halfway into the discussion, teachers began to explore the topic of student discourse and what it actually looked like in their classrooms. They asked questions to confirm their ideas about what had happened in their lessons, as well as what should happen. I provided a review of the math talk moves presented in the workshop. Interestingly enough, few remembered this part of the training. We discussed how to use some of the strategies, and the teachers again asked clarifying questions and expanded on the ideas discussed using specific instances in their classrooms as examples.

Analysis

The first observation from the transcript and notes from the session was that Ms. Anderson participated minimally in the discussion. She nodded and appeared to be listening, but there was only one occasion in which she offered a verbal comment in the discussion. Mr. Waters began participating about halfway into the discussion and provided significant contributions. Ms. French dominated the discussion at the beginning and participated in a significant way throughout.

I noted indications of agreement or understanding from each participant. These consisted, for the most part, of verbal “um hums” accompanied by nods of agreement. Mr. Waters indicated agreement 12 times and Ms. French 11 times. In addition, the participants asked clarifying questions or expanded on the student discourse ideas being discussed. Ms. French offered individual clarifying questions or suggested expanded explanations 23 times. Mr. Waters offered seven additional individual clarifying questions or suggestions, and Ms. Anderson did so once.

Themes that dominated this session were information about the intervention, research, and feedback. I provided the teachers with rubrics and their initial feedback graphic, and we discussed both the intervention and how feedback would occur. A secondary theme was about how teachers can support student discourse in the classroom.

I provided a list of strategies they could try, as well as examples from observations. We then discussed some of their attempts at facilitating discourse. Mr. Waters and Ms. French participated in the discussion both by clarifying their intent, asking questions about how to handle situations, and expressing relief at the validation received. Another secondary theme was the idea of gradual release of responsibility with students as they learned to solve problems on their own. I presented the scenario, and Ms. French and Mr. Waters joined in the discussion and expressed agreement. Several times Ms. French expressed frustration at not having access to the information and intervention earlier in the school year.

Conclusions

Based on the amount of participation, Ms. French seemed to be the most impacted by the discussion and perhaps the intervention. In her efforts to understand the techniques and the reasoning for student discourse, she seemed to be genuinely interested in understanding the techniques and making appropriate changes in her lessons, as well as understanding exactly how to use the feedback data to achieve higher scores on the rubric:

Ms. French: Can I ask a question I have about mine?

Coach: Yes!

Ms. French: The D, where the D says, I think, if I make sense of what your comments were about, I mean, when you e-mailed back to me, and said, "maybe when I do groups like that to assign roles to make sure that students are participating and understanding where they are a part in the process." Is that why the D looks like it does?

Coach: Yes, yeah.

Ms. French: While they're all talking you can tell that some are just sitting while other one's going, "hey it's this, this, and this."

Coach: Yeah, well so that's why I like to assign feedback, and one of the suggestions for a lot of the student talk research and whatnot is when you have small-group discussions, make everyone responsible for participating and giving roles is the easiest way to do that. That's kind of why I said that.

Ms. French: Okay.

Mr. Waters also appeared interested in the discussion, but perhaps because he wanted to confirm that what he was doing in the classroom was okay. Being a relatively new teacher, he did not seem to have the confidence of the others:

Coach: One thing I saw in one of the classes, I think it was your class [indicates Mr. Waters], when a student was always volunteering, "This is how I did," he, he showed and facilitated one way and the students said, "Well this is how I did it, I did it this way." And then another student offered something up and then another asked the first student, "So wait, what were you doing? And this?" And that's kind of how you get there. That's like the highest level of the rubric. That the students are thinking about what other students are saying rather than just looking at the teacher as all-knowing, all-being, you know which we love, but it isn't necessarily having the students think about what they are doing.

Mr. Waters: So that was actually a good thing. I didn't know.

Coach: I know, I know, it's tough too. And sometimes when they say something wrong, you're like, "Oh, Lord have mercy we are going down a rabbit hole," so it's a fine line. That's why teachers find it so stinking hard. You're like monitoring, reacting, you've got a plan; we're now off the plan.

Teachers: Umm, yeah

Coach: So you have to decide, you know, how to deal with if she said something, which she did, she said, "You know this is what I do in my head, I do this and this and I don't understand," and so you say, "I am glad that worked for you on this problem," and what we are saying is "showing work" is not "I figured it out," so then I broke down: "Well, that could be justification, but really what we want to do is get in the habit of showing our work so when the numbers get harder and we can't do it all in our head or we are on a test and we want to make sure we get it all right."

Ms. French: You kicked into parent mode.

Mr. Waters: I wanted to tell her to be quiet.

Coach: You didn't though.

Mr. Waters: She kept saying, she kept saying, “I did it.” What? What?

Coach: Okay I couldn’t hear him.

Ms. French: We are asking, “How does that apply?”.

Mr. Waters: He had it, he had it on his paper, and he kept having the right answer. And I, you know what; I thought you know what, what we talked about last time. He’s saying, what he’s saying might not be such a bad thing. ‘Cause he had the right answers but he came up with it a totally different way. The way he came up with the answer is totally off base. But he said, ”Well I did this, then I did this, and then I reversed, then I came up with this.” And I said, “What?” But I think that sometimes kids have a language that adults don’t use…

Coach: Right.

Mr. Waters: So someone else it the class might have understood what you’re saying.

Coach: Right. So you could ask, ”Does anyone else in the class understand what he was saying?”

Mr. Waters: Can you say it again? And that’s what I’m saying.

Coach: But with the new standards, I want you to know that we really want to respect alternate approaches to problem-solving. (March 25 PLC transcript, 2015)

Ms. Anderson’s minimal participation made it difficult to conclude if she was learning or growing from the discussion or even if she was interested in it.

April 2, 2015 PLC Feedback Session

Summary

The second feedback session was on April 2, 2015. During the teachers’ PLC time, we met to discuss as a group my observations and for me to provide some general suggestions. Mr. Kaye was unavailable because he had a meeting to attend for his new position in the district. In addition to Ms. Anderson, Ms. French, and Mr. Waters, two other sixth-grade math teachers attended the PLC. They were Mr. Gifts and Ms. Stream.

When I arrived for the PLC, teachers were already deep in discussion about the STAAR Blitz format and whether or not it was working. While the focus of the intervention was student discourse, the goal was to improve student performance. For this session, I let the teacher concerns guide the discussion. It had been a difficult week, and students had not done well on the independent practice during the Blitz. As a result, teachers found themselves reteaching on Thursday what they had taught on Tuesday—which was a review of what they had taught earlier in the year. Concerns were also raised about student behavior deteriorating as the extensive review continued. I expressed my concern about teachers working too much of the problems for students and suggested that less scaffolding might be more appropriate at this point to allow students to begin to take the responsibility for learning. We discussed different questioning techniques and physically active instructional strategies to help with these concerns.

Interestingly, when the bell rang, signaling the end to our PLC, the teachers remained and continued to discuss their concerns and possible solutions. The specific suggestions made were related to student discourse, planning productive student-to-student discussions, questioning to facilitate student-to-student discussions, and open-ended questions. I also introduced the lesson reflection form and passed it out to the participating teachers.

Analysis

In this session, the format ended up being much more conversational, with teachers directing the content by asking questions and expressing concerns, following up on one another's statements, and seeking my input only occasionally for clarification or alternative suggestions. In the discussion, Ms. French was still dominant in the discussion, but the other teachers participated much more. Specifically, Ms. French asked questions or provided ideas and information 18 times. Mr. Waters did the same eight times and Ms. Anderson six times. Clarifying questions from the teachers were less frequent, with Ms. French asking five and Mr. Waters only two. Mr. Waters participated and agreed 12 times with what was being said by me and other teachers. Ms. French expressed verbal agreement four times and Ms. Anderson once. The other teachers in the session also offered ideas and suggestions 14 times, asked clarifying questions five times, and agreed with statements nine times.

Themes in this session included more teacher input and other teacher input (teachers not part of the intervention, but who participated in the PLC session). Testing strategies questions and suggestions dominated the discussion. Teachers seemed focused on the upcoming local assessment and the state assessment just a few weeks away. For the first time, the theme of students not being capable of doing the work came up with Ms. Anderson and some of the other teachers in attendance. Mr. Waters and Ms. French expressed a slightly different version of this theme: they still can't do it—indicating that they believed students had the possibility for future success. Gradual release of responsibility reoccurred briefly in this session, but strategies to engage restless students was also a major theme in this session, with coach suggestions and input from participant teachers and other teachers. There were a few requests from teachers for strategies to help students with computations, which the coach provided.

Conclusions

It seemed that the conversation was very interesting to the teachers because they stayed well into their lunchtime to continue discussing how to help students improve their understanding of mathematics and their performance. My goal for the session was to demonstrate more ways to improve discourse in the mathematics classroom. Instead, the session was the demonstration. Teachers became the questioners rather than me (the coach). Teachers increasingly explained and articulated their ideas about mathematics teaching. While I was still a source of ideas related to strategies for teaching mathematics, the teachers were also making suggestions and asking each other about their statements; they definitely influenced the direction of the discussion. If this session were scored on the Math Talk Community rubric of Hufferd-Ackles et al. (2004), it would receive the highest ratings.

Mr. Waters shared his concern about the skills and knowledge his students seemed to lack and how to change the situation. At this point, Ms. French offered to the group how she had planned guiding questions for use in her classroom as she circulated among the groups. The goal of her guided questions was to help initiate student thinking and discussion. She shared that the groups with which she had shared the questions were indeed more successful on the independent practice:

Coach: What you want to do is get them talking and prompting them to talk, but not telling them too much to do.

Mr. Waters: Um hum. That's what I having a hard time figuring out what to do.

Ms. French: It's the questions. I typed out the guided questions, the questions we used for our Monday, Tuesday, okay, and we prompted the kids to talk about what do you know, what is the ratio, how to use an inverse operation, all of the things, that what is it, how is it used? And we prompted them to have these conversations. You know, now let's apply that to the problem. When we looked at the problem, you just said...

Coach: Right.

Ms. French: You just said, and I had all kinds of kids saying, "Oh I know how to do it now, oh!"

Coach: So when you did independent practice, were they more successful, that group?

Ms. French: They were definitely more successful, the group that I prompted with guided questions.

Following Ms. French, other teachers offered their suggestions to the group. This exchange provides evidence that Ms. French now views facilitating student discourse as an important component of supporting students learning. It also indicates that she had reflected on this idea and intentionally planned some questions in preparation for the lesson to facilitate discourse. Finally, when I asked how the students had responded, she shared that she felt the groups with which she used the questions were much more successful.

In another portion of the discussion, Ms. French provided feedback on her efforts to shift the responsibility for thinking and learning to students. She shared her discovery about what happened when her students initially encountered issues with multiple-choice items:

Ms. French: What I have seen this week, you know when you talked about shift to them thinking. They will answer the problem that I have on the board and they'll look and say, "Well that's not an answer choice. So that's not there, then I must be wrong" instead of thinking, "How can I write that a different way?".

Coach: Right?

Ms. French: How can I set up the subtraction another way?

In this exchange, it seemed that, had she not listened with some of the new discourse strategies, Ms. French might not have had the insight that her students lacked the confidence and resilience in order to try other approaches to solving a problem.

In addition to student discourse facilitation and questioning strategies, the teachers asked about and addressed many other issues, from behavior and engagement to alternative strategies for division. Their desire to help students improve their understanding of and performance in mathematics was evident in their openly sharing concerns and offering strategies to one another. They expressed concerns about the Blitz format and if it was still helping students, but were willing to work together to find alternative approaches to meet their students' needs.

CHAPTER V

CONCLUSIONS

Exploring the problem space clarified not only the problem, but also the values in the situation. This enabled me to focus on the portion of the problem of improving mathematics instruction that Region 10 ESC can impact. Providing teachers with professional learning to improve their mathematics instruction through facilitation of student discourse required more than our traditional professional development workshops. More support and follow-up appears to be required, especially for struggling teachers, to support changing their beliefs about the importance of student discourse and their implementation of strategies to facilitate student discourse for learning mathematics concepts. This support and follow-up was provided using a coaching model. Four sixth-grade mathematics teachers participated in the follow-up coaching, which consisted of four classroom observation and feedback opportunities over several weeks and three PLC sessions, in which information was shared, ideas discussed, and issues aired.

The research questions related to whether there were changes in teacher beliefs about student discourse and changes in teacher actions in the classroom to facilitate student discourse. Hull et al. (2009) suggested that an instructional coach's role in the change process should be helping teachers change their beliefs and associated actions. Teacher beliefs were explored through reflection responses from pre- and post-intervention questions, as well as during verbal discussions throughout the intervention. Teacher actions were monitored using Hufferd-Ackles et al. (2004) Math Talk

Community descriptors and Marshall's (2013) instructional and discourse factors. These values, as well as observation notes and records, were analyzed in a case study of each teacher to identify changes in discourse ecology in the individual mathematics classroom.

For each teacher participant, the first observation was actually more of a pre-intervention observation—teachers had participated in professional development, but had not been coached. In this first observation and in their responses to the pre-intervention reflection prompts, I was able to begin to form an understanding of teacher perceptions and practices. These were further clarified in follow-up discussions. Mr. Kaye is an experienced and confident teacher, seamlessly controlling interactions in his classroom with respect for all students and demonstrating mathematics content knowledge. Ms. Anderson is struggling with classroom management issues and seems uncertain as to how to engage students in learning mathematics. The special education teacher in her classroom even interrupted on a few occasions to chastise the students. The techniques she uses show promise, but many student behaviors border on being out of control. Mr. Waters is a first-year teacher, but has the respect of his students, even if he does not appear as comfortable implementing classroom management actions. With some success, he is already naturally using strategies that facilitate student discourse. Ms. French is also an experienced and confident teacher eager to participate in the intervention and try new strategies. She even stated in her reflections that she remembered from the workshop what to do to facilitate quality student discourse, but was not using any of the strategies.

In the PLC feedback sessions, teachers shared their desire to improve instruction and help students. The teachers expressed some frustration about student restlessness and discipline issues generally attributed to the intensity of the STAAR Blitz format and perhaps the time of year. Teachers began focusing on testing strategies and how to provide last-minute support to students. This led all involved to conclude that this type of intervention would have been more helpful earlier in the year.

In spite of the differences in teaching experience and expertise, all teachers showed an increase in some, if not all, indicators of discourse ecology at the end of the intervention. In addition, all shared a change in beliefs, specifically an increased awareness of student discourse and its utility in helping students construct mathematical concepts. All were allowing for and encouraging more student-to-student discourse and more opportunities to contribute meaningfully to whole-group discussions.

In my role as a facilitator of professional development, it was refreshing to provide this intervention to all the teachers. As described in the problem statement, it seems that much of what I do in traditional and online professional development sessions has no real impact on classroom instruction and therefore on student learning. However, the follow-up coaching intervention allowed me to individually observe and assist teachers in their professional growth. Supporting teachers as they attempt to implement new strategies through classroom observations and providing feedback in the form of data and suggestions has allowed me to facilitate individualized and effective professional learning. Based on the analysis of the data, it would seem that coaching follow-up to traditional workshop-style professional development may have some merit in helping teachers incorporate new discourse strategies and change their beliefs about the importance of discourse in the mathematics classroom.

Please note that the relationship I established with the participants, while critical in the coaching process, affected the analysis. Also, this case study method was not intended to generate generalizable results. Instead, the intent was to understand the lived experiences of the teachers as they attempted to change instruction.

The experience of providing the intervention and attempting to understand the teacher experiences and what made the difference to empower them to make changes in the classroom has encouraged me to make changes in many dimensions of my work as an educational consultant. I have read additional literature about coaching and have incorporated it into my instructional coaching. I have included opportunities in the online course I created to require participants to actually try some of the discourse strategies, reflect on the experience, and report back via the course. This has been particularly helpful for teachers and insightful for me as I continue to understand how we may effectively and efficiently facilitate improvements in mathematics instruction.

The intervention as provided may not work for all classroom teachers in all situations. It may also not apply to other types of instructional strategies. However, the success at this campus may encourage Region 10 ESC to consider this type of follow-up service to the traditional professional development workshop. This may be a service that we offer to all participants or perhaps as a service for teachers in need of improvement. Regardless, this is a personnel-intensive intervention and may not be an option for all teachers desiring change. In an effort to provide teachers support in their efforts to improve instruction, I have created video resources and additional professional learning opportunities via the Region 10 ESC Online Learning Center. For this to be effective, teachers must look for the resources.

A summary of what was learned through the intervention and subsequent reflection on potential opportunities was provided to my supervisors at Region 10 ESC and is attached in Appendix C. The Instructional Services Team has been considering service offerings to enhance the effectiveness of the professional development we provide. I am awaiting a response to my proposal.

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APPENDIX A

MOST SIGNIFICANT RESEARCH AND PRACTICE STUDIES

Barkley, S. G., & Bianco, T. (2009). *Questions for life: Powerful strategies to guide critical thinking*. Cadiz, KY: Performance Learning Systems, Inc.	This text organized questions into categories and suggests how to use this understanding of categories to create a plan to facilitate conversations for change in education.
Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Acadmey Press.	This text contained research on learners and learning. Of particular interest are specific elements of student learning and teacher learning—transfer of knowledge, eight factors affecting development of expertise (p. 237), teaching for in-depth learning, expert teachers, and technology.
Brantlinger, A. (2014). Critical mathematics discourse in a high school classroom: Examining patterns of student engagement and resistance. *Educational Studies in Mathematics* (85), 201–220.	Brantlinger studied the evolution of student discourse in an alternative high school for at-risk students by exploring the micro-level patterns of discourse and how students were positioned discursively. He noted increasing student ownership for learning but also resistance from some students at the change in roles in the classroom and the increased effort required.
Bruce, C.D., Esmonde, I., Ross, J., Dookie, L., & Beatty, R. (2010). The effects of sustained classroom-embedded teacher professional learning on teacher efficacy and related student achievement. *Teaching and Teacher Education*. (26), 1598–1608.	The authors concluded that their research "illustrates that sustained professional learning programs that are collaborative and classroom-embedded support effective professional learning that leads to substantial student achievement gains and the related gains in teacher quality" (p. 1607).
Bruton, L. (1984). Mathematical thinking: The struggle for meaning. *Journal for Research in Mathematics Education*, 15(1), 35–49.	Burton described mathematical thinking, the relationship between mathematical thinking and mathematical content. He also addressed the question of whether mathematical thinking can be taught. He concluded that students verbalizing their exploration and teachers developing a questioning

	atmosphere facilitate the development of mathematical thinking.
Chapin, S. H., O'Connor, C., & Anderson, N. C. (2009). *Classroom discussions: Using math talk to help students learn*. Sausalito, CA: Math Solutions.	This text, intended for K–6 mathematics classrooms described tools of classroom talk or "math talk moves" that provide specific strategies for teachers to use in the mathematics classroom to encourage student discourse and deeper thinking about mathematical concepts. This resource was used to inform the initial workshop professional development.
Chen, C., & Herbst, P. (2013). The interplay among gestures, discourse, and diagrams in students' geometrical reasoning. *Educational Studies in Mathematics* , 83, 285–307.	This work attempted to describe how students discuss and learn geometric concepts through the use of verbal communication and gestures, the role gestures play in making meaning, and how gestures are used differently in different situations. Gestures were diagrammed and synchronized with parsed transcripts coded according to the type of thinking the language suggested. A comparison was made between the presentation of a proof on the board from the homework in an intact lesson to the reasoning students constructed using an intervention diagram and question. This study identifies gestures and oral language used in conjunction with diagrams in making conjectures, demonstrates the role gestures play in the conjecture process, and highlights the importance of gestures in creating mathematical understanding.
Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (Third ed.). Los Angeles, CA: Sage.	Creswell focused on narrative research, phenomenology, grounded theory, ethnography, and case study. He also provided philosophical assumptions, interpretive frameworks, design approaches, and examples.
Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011).	This edition of SAGE provided examples of

The SAGE handbook of qualitative research (Fourth ed.). Los Angeles, CA: SAGE.	qualitative methods that will help clarify methods and issues of validity.
Gallucci, C., DeVoogt Van Lare, M., Yoon, I. H., & Boatright, B. (2010). Instructional Coaching: Building Theory About the Role and Organizational Support for Professional Learning. *American Educational Research Journal* , *47* (4), 919–963.	This article discussed the relationship between individual learning and organizational support and studied instructional coaching as a model for professional development. The study was a four-year case study of professional learning and observable changes in instruction and teacher perceptions.
Hall, P., & Simeral, A. (2008*). Building teachers' capacity for success: A collaborative approach for coaches and school leaders*. Alexandria, VA: ASCD.	This text provided a guide for instructional coaches through the lens of coach and administrator. It also described a continuum of teacher quality based on teacher awareness.
Hancewicz, E. (2005). *Discourse in the mathematics classroom. Literacy strategies for improving mathematics instruction* (pp. 72 - 86). Alexandria, VA: Association for Supervision and Curriculum Development.	Chapter 5—Discourse in the Mathematics Classroom. Hancewicz provided examples of discourse through classroom scenarios including conceptual understanding, computation, and problem-solving. She also emphasized consideration of the importance of vocabulary in discourse and using concept maps to foster discourse. Figure 5.5 provided a table of student and teacher roles in classroom discourse.
Hansen, P., & Mathern, D. (2008). Shifting roles and responsibilities to support mathematical understanding. *Teaching Children Mathematics* , *15* (3), 162–167.	Authors described the experiences of teachers, administrators, and the instructional coach in the process of change at a campus as they worked to incorporate more genuine problem-solving tasks facilitated by mathematics teachers.
Hansen-Thomas, H. (2009). Reform-Oriented mathematics in three sixth grade classes: How teachers draw in ELLs to academic discourse. *Journal of Language, Identity, and Education*, 8, 88–106.	This author used a qualitative, case-study format with an ethnographic perspective to study discourse using Connect Mathematics Project (CMP) curriculum, which appears to support student discourse within the context of middle-school classrooms with majority ELLs using the Community of Practice (CoP) model. Results show that teachers supported CoP by eliciting student

	participation and modeling discourse. Researchers counted utterances and classified them in subgroups of eliciting and modeling. The successful teacher spent a greater percentage of time eliciting application of concepts in standard form than modeling—the opposite of the less successful teachers.
Heck, D. J., Banilower, E. R., Weiss, I. R. & Rosenberg, S. L. (2008). Studying the effects of professional development: The case of the NSF's local systemic change through teacher enhancement initative. *Journal for Research in Mathematics Education*, 39(2), 113–152.	This paper describes the qualitative study of the effectiveness of National Science Foundation (NSF)–funded programs designed to improve classroom instruction. The researchers used data from 48 different projects and almost 18,000 participants. The researchers consider attitudes toward teaching, perceptions of content, and pedagogical preparedness, as well as self-reported uses of different teaching practices.
Hiebert, J. (1992). Chapter 3 Reflection and communication: Cognitive considerations in school mathematic reform. *International Journal of Educational Research.* 17(5). 439–456	Described the cognitive psychological theory behind reflection. Quoted Dewey on the importance of reflection about connections between concepts and Piaget on teaching of mathematics requiring students to "reflect consciously" on mathematical structures (p. 441). Discusses communication as "social cognition," especially when students must defend their ideas. "Classroom discourse is essential for engaging students in mathematics" and "plays a significant role in learning mathematics," suggesting that students "construct knowledge and understanding working collaboratively that they would not develop working alone" (p. 444).
Herbel-Eisenmann, B., & Cirillo, M. (Eds.). (2009). *Promoting purposeful discourse: Teacher research in mathematics classrooms*. Reston, VA: The National Council of Teachers of Mathematics.	This text is a collection of articles written by participants in Herbel-Eisenmann's project on discourse. Topics include essential ideas about classroom discourse, process of change, tensions in change, productive discourse, and selective listening. The group began by considering the

	"performance gap" or the discrepancy between teacher intention and teacher behavior (p. 20). It is a key contributor to the "Reflecting and Connecting with Practice" guided portions of the text. This kind of reflection may be a key component of the feedback sessions.
Herbel-Eisenmann, B., & Otten, S. (2011). Mapping mathematics in classroom discourse. *Journal for Research in Mathematics Education*, 42(5), 451–485.	Introduced and applied thematic analysis to data from two mathematics classrooms to identify shifts in mathematical focus, single mathematical idea, and where primary emphasis occurs (lexical chain) in order to identify "the ways in which mathematics is construed in classroom discourse" (p. 454).
Hufferd-Ackles, K., Fuson, K. C., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education* , 35 (2), 81–116.	The research design was a case study that initially considered four teachers but during data analysis began to focus on one teacher who showed significant growth in the development of discourse in her classroom. Researchers identified four components of a math-talk community as (a) questioning, (b) explaining mathematical thinking, (c) sources of mathematical ideas, and (d) responsibility for learning. Researchers then identified four levels of competency within each of the components and noted the characteristics of each level, as well the duration of each in the classroom. With the aid of the curriculum, the classroom math talk community quickly progressed from a Level 0 (very traditional, teacher-centered approach) to a Level 1. The transition to Level 2 took approximately eight weeks and represents the greatest shift in the classroom from teacher-centered to student-centered. The shift from Level 2 to Level 3 required three months. Researchers noted that mathematics must be accessible to students for them to be able to participate in meaningful discussions (zone of proximal development).

	Researchers provided a set of strategies the teacher used for transitioning the classroom from one level to the next. Table 1 provides a rubric of sorts for evaluating the level of "math talk learning community" in the classroom that evaluated questioning, explanations of mathematical thinking, source of mathematical ideas, and responsibility for learning [similar to Kazemi (1998)].
Hull, T. H., Balka, D. S., & Miles, R. H. (2009). *A guide to mathematics coaching.* Thousand Oaks, CA: Corwin.	Text provided specific guidance for mathematics coaches including critical stages of building rapport, focus on curriculum and its planning/implementation, examining student work, and the change process. Of particular interest is the chapter on making student thinking visible and how difficult it is to infuse lessons with the described characteristics.
Jackson, K., Garrison, A., Wilson, J. Gibbons, L., & Shahan E. (2013). Exploring relationships between setting up complex tasks and opportunities to learn in concluding whole-class discussions in middle-grades mathematics instruction. *Journal for Research in Mathematics Education*, 44(4), 646–682.	Studied 165 middle school math teachers and found a relationship between how complex student tasks were introduced and level of cognitive engagement of student learning. They concluded that "the quality of the attention to mathematical relationships in the setup was generally positively related to the quality of the concluding whole-class discussion …between the quality of the setup and the quality of the concluding whole-class discussion regardless of whether the task included a problem-solving scenario…and teachers were more likely to attend to the mathematical relationships than the contextual features" (p. 677), to which the authors concluded that the cognitive demand of the task being lowered.
Joyce, B., & Showers, B. (2002). *Student achievement through staff development* (Third ed.). Alexandria, VA: ASCD.	This text considered professional development with a focus on student performance. Of particular interest were designing training/peer coaching and

	using inquiry/evaluation to determine student understanding.
Joyce, B., Weil, M., & Calhoun, E. (2009). *Models of teaching* (Eighth ed.). Upper Saddle River, NJ: Pearson Education.	Provided models of teaching categorized by learning environments. Of particular interest are inductive thinking, concept attainment, group investigation, and direct instruction.
Kazemi, E. (1998). Discourse that promotes conceptual understanding. *Teaching Children Mathematics*, 4(7), 410–414.	"Four socio-mathematical norms that guided students' mathematical activity and helped create a high press for conceptual thinking: • Explanations consisted of mathematical arguments, not simply procedural summaries of the steps taken to solve the problem. • Errors offered opportunities to re-conceptualize a problem and explore contradictions and alternative strategies. • Mathematical thinking involved understating relations among multiple strategies Collaborative work involved individual accountability and reaching consensus through mathematical argumentation")p. 411).
Knight, J. (2012, February). *Notes on Instructional Coaching*. Retrieved from http://jimknightoncoaching.squarespace.com/	This Website provided tips for instructional coaching as part of his professional blog.
Lieberman, A., Hanson, S., & Gless, J. (2012). *Mentoring teachers: Navigating the real-world tensions*. San Francisco, CA: Jossey-Bass.	This text described the tensions of a being a mentor, from leaving the classroom through the development of leadership skills.
Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics* (Third ed.). Thousand Oaks, CA: Corwin.	This text focused on development of math and science teachers. It described a variety of research-based practices for effective professional development as well as critical issues.

Marshall (2013). *Succeeding with inquiry in the science and math classrooms*. Alexandria, VA: ASCD.	EQUIP Rubric as well as descriptions of the program and results. Note that the EQUIP rubric is also available as an app from iTunes. This research provided an informative rubric by which I could measure discourse ecology as well as other instructional strategies to determine change over time.
Mendez, E. P., Sherin, M. G., & Louis, D. A. (2007). Multiple perspectives on the development of an eight-grade mathematical discourse community. *The Elementary School Journal*, 108(1), 41–61.	The research focused on the development of mathematical discourse in an eighth-grade mathematics classroom through analysis of classroom interaction/discourse and teacher reflection. Analysis of classroom discourse used the author-developed RMD framework that quantified mathematics dimension (representation, generalization, and justification) and discussion dimension (engagement, intensity, and building). Professional vision of classroom discourse (PVCD) another author-created tool was used to analyze teacher attention to and reflection on student talk. This aspect shows promise in identifying why good teachers don't get good results.
National Council of Teachers of Mathematics (2013). *What are some strategies for facilitating productive classroom discussions?* Research brief. Posted January 23, 2013.	This research brief provided a summary of specific strategies and considerations, based on an extensive list of literature, for mathematics teachers who wish to improve productive classroom discussions. This resource was used in preparing the afterschool professional development workshop.
Neuberger, J. (2012). Benefits of a teacher and coach collaboration: A case study. *The Journal of Mathematical Behavior , 31*, 290–311.	Provided a planning, lesson, and debrief model for instructional coaching. Example case study demonstrated teacher beliefs and practices changed throughout the coaching provided.
Nichols, M. (2014). Real talk, real teaching. *Educational Leadership*, 72 (3), 73–77.	This article provided encouragement to teachers to engage in student discourse while sharing five "predictable problems": everyone's talking at once, no one's listening, some students dominate, the

	"right answer" paradigm prevails. This was a helpful resource to share with teachers.
Omohundro Wedekind, K. (2011). *Math exchanges: Guiding young mathematicians in small-group meetings*. Portland, ME: Stenhouse.	Figure 5.4 detailed "teacher moves" that support student dialogue. The table listed teacher language, purpose and "look-fors" /follow-ups for three phases: initiating dialogue, follow-up after a student has shared a strategy, and eliciting more information from a student who has shared an idea. While the text is directed toward early primary teachers, the concepts can be easily extended to work in secondary classrooms.
Pascale, R., Sternin, J., & Sternin, M., (2010). *The power of positive deviance: How unlikely innovators solve the world's toughest problems*. Boston, MA: Harvard Business Press.	This text described the positive deviance model and its potential to solve problems when the solution requires behavioral or social change. The text provided guidelines for studying successful outliers to identify solutions and through this effort empowering individuals to make the decision to change behavior.
Piccolo, D. L., Harabaugh, A. P., Carter, T. A., Capraro, M. M., & Capraro, R. M. (2008). Quality of instruction: Examining discourse in middle school mathematics instruction. *Journal of Advanced Academics*, 19(3), 376 – 410.	The results of the analysis generated the DSTCP map and tables for teacher-initiated interactions and student-initiated interactions. Researchers identified five groups of pathways with teacher-initiated interactions with results ranging from confirmation of factual knowledge to facilitating rich mathematical conversations and understanding. They also identified four groups from student-initiated interactions (one of which is identical to one of the teacher-initiated pathways). Researchers found "persistent" questioning in both sets of pathways that "led to a level of discourse perceived to be at a deeper conceptual mathematical level" (p. 402). The student-initiated and persistent questioning support previous research that suggest that students need to hear the teacher and to articulate their own understanding and thus should

	be a goal of teachers. They recommend that teacher should be guided to include the types of discourse pathways that result in rich discourse with the assistance of more successful teachers and perhaps through action research.
Polly, D., Neale, H., & Pugalee, D. K. (2014). How does ongoing task-focused mathematics professional development influence elementary school teachers' knowledge, beliefs and enacted pedagogies? *Journal of Early Childhood Education*, 42, 1–10.	This study examines changes in teacher beliefs after participation in an elementary professional development focused on teacher practices to support cognitively demanding tasks and questioning. Used Mathematical Knowledge for Teaching (MKT) assessment of teacher content and pedagogical knowledge, as well as Teacher Belief Questionnaire (TBQ) and Teacher Practice Questionnaire (TPQ) survey instruments.
Polly, D., Wang, C., McGee, J., Lambert, R. G., Martin, C. S., & Pugalee, D. (2014). Examining the Influence of a curriculum-based elementary mathematics professional development program. *Journal of Research in Childhood Education*, 28, 327–343.	This study examines changes in teacher beliefs after participation in an extended professional development. The research questions ask about the extent to which the professional development influenced participating teacher beliefs about mathematics teaching and learning, self-reported instructional changes, and student outcomes. Used TBQ and TPQ survey instruments based on Swan (2006).
Sarason, S. B. (2004). *And what do you mean by learning?* Portsmouth, NH: Heinemann.	In this text, Sarason described contexts of learning in and through interactions among people. She also addressed disconnect between leadership expectations and learning in the classroom.
Sherin, M. G. (2000). Reflections on practice: Facilitating meaningful discussion of mathematics. *Mathematics Teaching in the Middle School*, 6(2), 122–125.	Sherin described structures for whole-class discussion. This can be used as an example of how to generate ideas, comparing and evaluating ideas, and focusing the range of ideas.
Tanner, H., & Jones, S. (2000). Scaffolding for success: Reflective discourse and the	The research was quasi-experimental design with pre-testing, post-testing, and delayed testing of

effective teaching of mathematical thinking skills. *Research in Mathematics Education* 2(1), 19–32.	control and experimental groups. It was noted that, as anticipated, teacher implementation of the strategies in their classrooms varied greatly. When teachers employ dynamic scaffolding, students effectively developed metacognitive skills. When teachers employ reflective scaffolding through the participation in reflective discourse students also learned that mathematics makes sense and could make their own "tentative conjectures and constructions linking them to prior schemata" (p. 29.) Thus they conjecture that "teaching approaches which support the development of active metacognitive skills in combination with passive metacognitive knowledge enhance…the learning of new mathematics" (p. 29).
Van de Walle, J.A., Karp, K. S., & Bay-Williams, J. M. (2013). *Elementary and middle school mathematics: Teaching developmentally*. Boston, MA: Pearson.	A comprehensive text summarized current approaches to mathematics content and pedagogy designed for use in professional learning.
Williams, S. R., & Baxter, J. A. (1996). Dilemmas of discourse-oriented teaching in one middle school mathematics classroom. *The Elementary School Journal*, 21–38.	The focus of the analysis was to examine what happens in the classroom of a "relatively successful" teacher at implementing "discourse-oriented teaching." The results document the teacher's beliefs, which included the value of hands-on experiential learning, students as the producers of knowledge, and the value of teacher reflection. The findings related to the classroom environment include a wide array of techniques to help students talk and think about mathematical ideas and a sequence of problem presentation, small-group work, and whole-class discussion frequently repeated. The students' view of the discourse-oriented teaching was meaningful discussion in which they build on each other's ideas and questioned each other's thinking—students

	provided scaffolding for other students.
Wood, T., Williams, G., & McNeal, B. (2006). Children's mathematical thinking in different classroom cultures. *Journal for Research in Mathematics Education*, 37(3), 222–255.	Studied the interrelationship between types of interaction patterns in the classroom and the nature of children's mathematical thinking expressed within these patterns (p.248). It is a quantitative-qualitative research paradigm with two coding schemes, one for analysis of interaction patterns (collect answers, funnel, give expected information, teacher explanation, hint to solution, exploring methods, argument, inquiry, teacher elaboration, proof by cubes, proof by pupil explanation, focus, building consensus, checking for consensus, develop conceptual understanding, pupil self-nominate) and the other for children's thinking (recognizing/comprehending, recognizing/applying, building-with/analyzing, building-with/synthetic-analyzing, building-with/evaluative analyzing, constructing-synthesizing, construing/evaluating). Analysis suggests that increased student involvement with concept results in deeper understanding.

APPENDIX B

STATEMENT OF IRB DISPOSITION OF THE PROPOSED STUDY

The following e-mails were received indicating IRB determination.

From: **Carol Stuessy** c-stuessy@tamu.edu
Subject: IRB Decision
Date: July 4, 2014 at 12:58 PM
To: bianca.coker@region10.org, alanellinger@neo.tamu.edu, mg-staley@att.net, dchender1974@tamu.edu, melross@neo.tamu.edu, brw@tamu.edu
Cc: Mary Margaret Capraro mmcapraro@tamu.edu, plarke@tamu.edu, vhjackson@tamu.edu

Dear Bianca, Alan, Michelle, Daphne, Melissa, and Billy,

The IRB has determined that your proposed ROS plans do not require IRB approval. Once the fall internship begins, you will be able to begin collecting information to frame your problems as soon as we complete preparations to "frame" your ROS problems. I would suggest that you re-read the documents associated with the Cohort III Interim Report and begin reading your text for the internship:

Cuban, L. (2001). How can I fix it? Finding solutions and managing dilemmas: An educator's road map. New York: Teachers College, Columbia University.

With my best regards,

Dr. Carol Stuessy, Director
Online Ed.D. in Curriculum and Instruction
Department of Teaching, Learning & Culture

Summary Table of Proposed Records of Study for
Ed.D. Cohort III Student

June 30, 2014

Student and Chair	Problem	Professional Role and Responsibilities of Student	Information to Frame the Problem	Possible Solutions to the Problem
Coker **(Capraro)** **CLEARED** **No IRB needed**	Poor performance in middle grade mathematics in Region 10 ESC	Mathematics consultant at Region 10 ESC, routinely providing PD and observing classrooms	Observe classrooms to identify teacher actions and student discourse in 7th grade mathematics classrooms	Professional learning and PD using information from observations

APPENDIX C

BIANCA COKER'S SUMMARY OF RESEARCH AND PROPOSAL TO INCREASE EFFECTIVENESS OF PROFESSIONAL DEVELOPMENT

Summary of Research

For the past four years I have been engaged in learning more about how to increase the effectiveness of the services we offer through coursework and research in the process of earning a Doctorate of Education in Curriculum and Instruction through Texas A&M. My journey has led me to understand the following about successful instruction:

- Content knowledge is critical for mathematics and science (Loucks-Horsley et al., 2010)
- Teachers want to be successful but each has unique needs
- Administrators want their teachers to be successful but each campus has distinct challenges
- There can be tensions between teachers and administrators about how to meet the needs of students, especially in stress-filled environments
- Successful teachers continue to reflect and revise their instruction, seeking information and support in their efforts to improve
- Struggling teachers retreat to traditional or familiar strategies, even when they fear they are being unsuccessful

I believe that in understanding these factors we can be more successful in facilitating changes in instruction and impacting student performance.

The mathematics consultants over the past three years have written trainings for each grade band focused on increasing effective student discourse in mathematics classrooms. Research described how students construct mathematical concepts, and talking about mathematics with their teacher and peers aids in this process (Bransford et al., 2000; Brantlinger, 2014; Bruton, 1984; Chapin et al., 2009; Hancewicz, 2005; Hansen & Mathern, 2008; Herbel-Eisenmann & Cirillo, 2009; Marshall, 2013; National Council of Teachers of Mathematics, 2013). While we continue to offer these traditional workshops, subsequent discussions with administrators and visits to mathematics classrooms revealed that some teachers are still offering very traditional teacher-centered instruction. Research also confirms what we observed: teacher professional development needs to be aligned, intensive, and ongoing to be effective (Darling-Hammond, 1999; Loucks-Horsley et al., 2010).

With this information, I designed a brief coaching follow-up to *Student Talk = Math Success*, the six-hour professional development workshop written in 2013, and offered it to former participants of the workshop. Four sixth-grade mathematics teachers at one of our districts chose to participate. The coaching intervention consisted of four classroom observations, feedback, and PLC facilitation. I used rubrics from research (Hufferd-Ackles et al., 2004; Marshall, 2013) to measure the discourse ecology in the lessons and provided focused feedback to the teachers. All teachers demonstrated an increase of at least one level in discourse ecology as measured using the rubrics. In addition, the teachers shared in reflections an increased awareness of the importance of student discourse in the process of learning mathematics.

Proposal for New Service Offerings

In an effort to be more effective in facilitating change in the classroom, I propose the following new service offerings be considered by Instructional Services:

- In-Person Coaching Follow-Up to Selected Workshops—four sessions each to include full lesson observation and feedback focused on the specific goals of the workshop
- Virtual Coaching Follow-Up to Selected Workshops—four virtual sessions each to include review of teacher-provided video recordings of lessons and feedback on the specific goals of the workshop
- Campus-Wide Coaching Follow-Up to Selected Workshops—four sessions each for all appropriate teachers based on the goals of the workshop to include lesson observations, individual feedback, and PLC facilitation with a focus on the goals of the workshop
- Coaching of Coaches Follow-Up—five sessions with campus or district instructional coach to focus on a specific strategy or goal, develop rubrics and provide assistance with observations and feedback with teachers, and guide in creating final analysis and report of coaching

I am available to discuss further or provide any additional information. Thank you for the opportunity and support you all provided in my professional growth.