2019

The Impact of Technology on the Implementation of Formative Assessment Lessons in Eighth Grade Math Classrooms

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THE IMPACT OF TECHNOLOGY ON THE IMPLEMENTATION OF FORMATIVE ASSESSMENT LESSONS IN EIGHTH GRADE MATH CLASSROOMS

A Dissertation
presented in partial fulfillment of requirements
for the degree of Doctor of Education
in the Department of Education
The University of Mississippi

by

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May 2019

ABSTRACT

Technology use has become commonplace in some mathematics classrooms, often being used for formative assessment. Research supports the use of technology to engage students, but not as much research exists to investigate the impact on student learning. The purpose of this study was to investigate whether a statistical relationship exists between the post-lesson assessment results of students engaging in a formative assessment lesson where the teacher delivers the lesson with technology and students engaging in a formative assessment lesson where the teacher delivers the lesson without technology. The teachers administered pre- and post-lesson assessments to the students after the formative assessment lesson enactments. The whole class introduction and whole class discussion took place with the teacher using technology to deliver the lesson for the control groups. The whole class introduction and whole class discussion took place without the teacher using technology to deliver the lesson for the experimental groups. This study also investigated teacher and student perceptions of the use of technology in the teaching and learning of mathematics. The teachers were interviewed to gather their perception of any implications resulting from their use of technology in the formative assessment lesson. Students completed a survey to express their views on the use of technology in a formative assessment lesson delivery. Observations of one experimental class and one control class took place during the formative assessment lessons for each teacher.

The quantitative data results of this research study were mixed in determining whether the use of technology in the delivery of phases of a formative assessment lesson had an impact on students' post-lesson assessment performance. The mixed quantitative results also did not conclusively indicate that technology use in formative assessment lessons impacted student performance on post-lesson assessments. The results of this study may raise questions of whether technology purchases are worth the investment. The implications from this research indicate that technology use in a formative assessment lesson does not necessarily impact student learning.

ACKNOWLEDGMENTS

"For I know the plans I have for you, declares the Lord, plans to prosper you and not to harm you, plans to give you hope and a future." Jeremiah 29:11 NIV

First and foremost, I thank God for opening this door and allowing me to walk through it. The journey that took me to this point has been an endeavor that I am happy I embarked upon. I want to thank my advisor, professor, and committee member, Dr. Allan Bellman, for pushing me beyond what I ever thought I could accomplish. I want to thank my professor and committee member, Dr. Tom Brady, for thought-provoking questions that always helped me to improve my work. I want to thank my professor and committee member, Dr. Amy Wells-Dolan, for the much-needed feedback that kept me striving for better. I want to thank my professor and committee member, Dr. Renee Cunningham, for the guidance and encouragement that prompted me to think beyond the simplest ideas. Without you all and my other professors this program could not have been a success.

In addition, I thank my cheering section that kept me striving toward this goal; I could not have done this without each of you. Thank you Christopher for always asking about my progress on all assignments; you kept me accountable. Thank you Christen for reading my work, listening and critiquing my presentations, and encouraging me to keep going. Your drive and strength gave me motivation to see this through to the end. Thank you LeKitia for believing in me and for constantly reminding me that I could do it.

Lastly, but certainly not least, I thank three special people who were instrumental in my work, Karin, Madeline, and Bo; you know what you did for me and I am so grateful. To my fellow classmates, Adrienne, Trisha, Jennifer M., Shawna, and Jennifer W., thank you for making this journey worthwhile. To my colleagues, co-workers, family members, friends and research participants, thank you for your assistance and encouragement along the way. To Lola, who was in my way and a distraction most of the time, I am thankful for you just being there.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

Introduction

Overview of the Study

Technology use has become commonplace in some mathematics classrooms. Teachers are using technology to simplify daily tasks, substitute for antiquated pedagogy methods, and enhance traditional lesson presentations. In mathematics classrooms, technology is used often for formative assessment. Research supports the use of technology to engage students, but not as much research exists to investigate the impact on student learning. This researcher became interested in exploring whether or not the effect of using technology in a mathematics lesson presentation made an impact on student performance.

The Southern Regional Education Board (SREB) offered the Mathematics Design Collaborative (MDC) to school districts in Mississippi to help with implementation of the Common Core State Standards of Mathematics. Teachers in this large school district in central Mississippi have been participating in the MDC cohort with other districts across the state for three years. Teachers participating in this collaboration are charged to enact Formative Assessment Lessons (FALs) in their mathematics classrooms. These lessons consist of five phases: 1) Pre-Lesson Assessment 2) Whole Class Introduction 3) Collaborative Activity 4) Whole Class Discussion 5) Post-Lesson Assessment. The lessons are designed for implementation without technology so all schools, regardless of their available technologies, can use them. The district in this study has a wealth of technology resources that the teachers include in their lessons on a regular basis. The teachers present most lessons using an interactive whiteboard and send and collect data from their students using a student response system. In this 1:1 district, students have access to a laptop computer daily. Because these teachers were using the FALs in their classrooms, the researcher was curious as to how the technology use in the lesson impacted the outcomes.

Teachers submit their results of lesson enactments through a data form that indicates student ratings from the pre-lesson assessment to the post-lesson assessment. There are also questions on the form for teachers to address common issues noticed from the pre-lesson assessment and what implications the post-lesson assessment data has on future instruction. During the formative assessment lesson enactment, teachers follow a lesson guide that provides sample questions to be asked during each phase of the lesson and sample student responses to those questions. The guide also provides suggested time durations for each lesson phase and lists all the materials needed for the lesson.

Technology's presence in the mathematics classroom does not mean it is being used with fidelity or that student success is guaranteed. The teachers in this study all have and use technology daily in their lesson delivery. Investigating the use of technology during a FAL will help this researcher understand if technology used to deliver instruction has an impact on student learning.

Statement of the Problem

Disagreement exists as to whether using technology in classrooms has any impact on student learning. Marc Prensky labels today's students digital natives. These students do not think or process information the same as students of the past, due to the evolution of technology (Prensky, 2006). In order for teachers, identified by Prensky as digital immigrants, to meet the needs of these students, teachers must adapt their teaching practice to accommodate this new way that students learn because of technology.

Purpose of the Study

A mixed-methods research design will be used in this study due to the benefits of collecting both quantitative and qualitative data (Mertler, 2017). The purpose of this study will be to investigate whether a statistical relationship exists between the post-assessment results of students engaging in a formative assessment lesson where the teacher delivers the lesson with technology and students engaging in a formative assessment lesson where the teacher delivers the lesson without technology. This study will also investigate teacher and student perceptions of the use of technology in the teaching and learning of mathematics. Studying these factors can inform teachers whether the use of technology in enacting formative assessment lessons impact student learning.

"Qualitative findings can be used to enhance quality, improve programs, generate deeper insights into the root causes of significant problems, and help prevent problems" (Patton, 2015, p. 205). Surveys will be used to allow students to share their thoughts and opinions about the classroom practices and their learning of mathematics content through technology use (Dana & Yendol-Hoppey, 2014). Students will be given a platform to express their voices about their preferences for how they best learn mathematics as it relates to teachers using technology to deliver a lesson. When teachers understand different strategies that students attribute to success in mathematics classes, teachers have more information to guide instruction. Through interviews, teachers will be allowed to provide their thoughts on technology use in lesson delivery.

Significance of the Study

Shirley and Irving (2015) assert that formative assessment can be difficult to carry out due to the "challenge of collecting and aggregating accurate data on student learning in a short time frame" (p. 57). Incorporating technology in the data collection during formative assessment may help teachers overcome this challenge. According to Shirley and Irving (2015), increased student engagement and enhanced dialogue between teacher and student are two benefits of classrooms connected to technology. Shirley and Irving (2015) also believe that students have deeper understanding and learn more when they are actively involved with their own learning with the use of connected classroom technologies (CCT), which they define as using a family of devices to facilitate formative assessment.

Research Questions and Hypotheses

The research questions primary to this study are:

1) Does teacher enactment of a formative assessment lesson using technology for delivery of the whole class introduction and the whole class discussion impact the students' performance on post assessments?

> H_0: There is no difference in the performance on post assessments for students participating in a formative assessment lesson enacted with the teacher using technology for delivery of the whole class introduction and the whole class discussion and students participating in a formative assessment lesson enacted without the teacher using technology for delivery of the whole class introduction and the whole class discussion.

2) What implications does the teacher perception of using technology to enact formative assessment lessons have on instruction?

3) What are student perceptions of technology use in instruction delivery of a formative assessment lesson?

CHAPTER II

Definition of Terms

Analyzing Student Data Form: The form, created by SREB for MDC teachers to complete after administering the pre- and post-assessments to students, used to record the student ratings to determine performance and inform future instruction (SREB, 2014).

Block Schedule: The researcher designates this as a 90-minute alternating day scheduling system by middle or high schools where students attend each class period for 90 minutes every other day.

Collaborative Activity: An activity that permits students to collaborate in small groups to individually and collectively achieve both common and individual academic goals by engaging in discussion, taking responsibility for their own learning, and learning from each other as they participate in creating posters, reviewing samples of student work, and card sorting and matching. For the purposes of this study, the collaborative activity is part of the formative assessment lesson that takes place between the pre- and post-lesson assessments and is intended to allow student collaboration through an activity and reveal student misconceptions to teachers (Kotsopoulos, 2010; SREB, 2014; Wilder, 2015).

Feedback: A clear and focused reply to a learner's work that is designed to elicit a cognitive response from the learner to help them know where they are in their learning and what they need to do to improve (Tomlinson, 2014).

Formative Assessment: A process through which assessment-elicited evidence of student learning is gathered and instruction is modified in response to feedback (Cauley & McMillan, 2009).

Formative Assessment Lessons (FALs) or Classroom Challenges: A classroom-ready lesson that supports formative assessment. They help teachers assess and improve students' understanding of mathematical concepts and skills and their ability to use the "mathematical practices" described in the Common Core State Standards (Mathematics Assessment Project, 2013).

Inclusion Class: The researcher designates this as a class consisting of students with disabilities being included in a general classroom setting to learn along with their non-disabled peers.

Lesson Enactment: The researcher defines this as the act of a teacher facilitating a formative assessment lesson to students.

Lesson Guide: A detailed outline that supports the teacher throughout the lesson, with specific suggestions, sample questions, and examples for each phase of the lesson (Mathematics Assessment Project, 2013).

Mathematics Design Collaborative (MDC): A collaboration with the Southern Regional Education Board (SREB) that provides schools with instructional tools needed to help teachers understand and implement college- and career-readiness standards effectively while allowing teachers the flexibility to select topics and adapt assignments to their specific instructional plans (SREB, 2014).

Pre-lesson Assessment: An initial assessment that provides teachers with a qualitative sense of their students' grasp of the targeted mathematics standards before the formative assessment lesson (SREB, 2014).

Post-lesson Assessment: An assessment administered after the formative assessment lesson where students apply what they have learned while providing teachers with feedback on the effectiveness of their instruction (SREB, 2014).

Student Response System: The researcher designates this as a network of hardware and software used through devices that allow the teacher to facilitate activities with students by sending and gathering information.

Whole Class Discussion: The summary taking place after the collaborative activity where students share their work and the teacher is allowed to delve deeper into the misconceptions revealed in the pre-lesson assessment (Wilder, 2015).

Whole Class Introduction: The start of a Classroom Challenge that includes a brief activation of student prior knowledge through questions that students respond to by displaying their answers on mini-whiteboards (Wilder, 2015).

Literature Review

Formative assessment has been a ubiquitous topic in the educational realm for the past few years. Journal articles, books, and videos are available in surplus for persons interested in finding more information about formative assessment. Some of the resources referenced by MDC include but are not limited to the formative assessment work of Dylan Wiliam. The literature investigates many aspects of formative assessment, including best practices for formative assessment, types of formative assessment, and some effects of using formative assessment. The literature review that follows attempted to connect the use of technology in formative assessment lessons.

Collaborative Learning

Students' working together to find common solutions is a primary goal of collaborative learning. Retnowati, Ayres, and Sweller (2017) believe "collaborative learning requires active social interactions, group goals, and individual accountability" (p. 667). They also state that there may be advantages to collaborative learning over students learning individually because collaboration allows students to share their thoughts with one another (Kotsopoulos, 2010; Retnowati, Ayres, & Sweller, 2017). In their research on collaborative learning from worked examples, Retnowati et al. (2017) found mixed results in student performances for those working collaboratively and those working individually. Collaborative learning did prove to be superior to individual learning for problem solving, but that was the only time in the research (Retnowati et al., 2017). Collett, Gearhart, and Buchanan (2018) further support that higher learning gains are found in classrooms where more students are allowed to present solutions, analyze reasoning and contribute new ideas to discussions.

In contrast, Kotsopoulos (2010) found that collaborative learning is often non-collaborative regardless of the task the teacher chooses or the instructional efforts. Meaning, because students are given a high quality task to collaborate in solving does not mean that students will actual work collaboratively. During the collaborative work, students are expected to explain their thinking while their group mates listen. Bahr and Bahr (2017) warn that teachers should not assume peers are engaged while listening to classmates' explanations.

Francisco (2013) looked at the assistance students are provided from peers when working in collaborative groups. Students are able to build from the ideas presented in the group, which helps them to form their own reasoning (Francisco, 2013). Wilder (2015) asserts that students engaging in collaborative groups are able to critique each other's reasoning and be responsible for their own learning as well as their peers' learning. Francisco (2013) cautions that placing student in groups is not enough, teachers may need to help facilitate a group's discussion without robbing them of their ideas and task ownership. In Classroom Challenges, one teacher role during the collaborative activity is to listen to the students' discussions and ask questions to encourage deeper thinking and reasoning without providing answers or solutions (MARS, 2013).

Feedback

Feedback is essential throughout the enactment of Classroom Challenges. Phillips and Wong (2012) proclaim the development of the formative assessment tasks in Classroom Challenges expose students to non-routine problems that allow teachers to provide students with ongoing feedback. Tomlinson (2014) contends students must be made aware of what they need to do to improve through formative assessment feedback.

Through Classroom Challenges, students are able to see each other's contributions to the task and receive feedback from one another immediately. McKnight et al. (2016) conducted a multi-site case study, which reported classroom discussions were enhanced when students had the ability to see feedback from their peers. Shirley and Irving (2015) add that student's ability to see their peers' responses to prompts may help with their own understanding. Cauley and McMillan (2009) further assert formative assessment feedback aids students in setting achievable learning goals.

Formative Assessment

The Southern Regional Education Board (SREB) has provided schools with instructional tools to implement college- and career-readiness standards through the Mathematics Design

Collaborative (MDC) (SREB, 2016). Through MDC, teachers engage students in a productive struggle with mathematics to help them "develop a deeper conceptual understanding of key math concepts that build fluency with their procedural skills and deepens mathematical reasoning and understanding" (p. 13). MDC encourages effective formative assessment using Wiliam's (2007) five key strategies: 1. Clarifying, sharing, and understanding goals for learning and criteria for success with learners 2. Engineering effective classroom discussions, questions, activities, and tasks that elicit evidence of students' learning 3. Providing feedback that moves learning forward 4. Activating students as owners of their own learning 5. Activating students as learning resources for one another.

The National Council of Teachers of Mathematics supports the use of formative assessment strategies in daily instruction (NCTM, 2013). NCTM (2013) defines formative assessment as "an essential process that supports students in developing the reasoning and sense-making skills that they need to reach specific learning targets and move toward mastery of mathematical practices" (p. 42). According to the Mathematics Assessment Project (2013), "research has shown that formative assessment is a powerful way to improve student learning and performance" (p. 2).

Despite the research that indicates formative assessment as a significant factor in improved student learning, some sources believe the fidelity in which we formatively assess should be considered. Ermeling, Hiebert, and Gallimore (2015) claim that U.S. teachers tend to present conceptual problems to students but the delivery of the problems is not taught conceptually as higher- performing countries do. The authors mentioned how Japanese teachers allow students to productively struggle with challenging problems before being taught procedurally. In contrast, they also referenced the 1999 Trends in International Mathematics and

Science Study (TIMSS) where classroom video revealed U.S. teachers "converted challenging problems into procedural tasks by frontloading lessons with specific formulas and rules that students could use to find right answers" (p. 49).

A multitude of research sources emphasizes the importance of feedback from formative assessment being used by teachers to adjust instruction to meet learning needs (Cauley & McMillan, 2010; Fennell, Swartz, Kobett, & Wray, 2015; Kazemi, Gibbons, Lomax, & Franke, 2016; Petit, Zawojewski, & Lobato, 2010; Phillips & Wong, 2012; Shirley & Irving, 2015; Tomlinson, 2014; Wilder, 2015; Wiliam, 2007). Schoenfeld (2015) adds that students should be provided feedback from formative assessment when there is still time for them to improve. Shirley and Irving (2015) insist that tasks and learning opportunities should expose students to deep thinking if the formative assessment data is to be effective. Kazemi, Gibbons, Lomax, and Franke (2016) advises that formative assessment data may not provide teachers with information about a students' approaches, thinking, and aspects of the problem they struggle with. In a study of whether formative assessment learning impacted summative assessment, Grosas, Raju, Schuett, Chuck, and Millar (2016) found minimal improvement on final exam performance for students actively participating in formative assessment processes.

Formative Assessment Lessons

Classroom Challenges (CC) formerly known as Formative Assessment Lessons (FALs) are lessons ready for the classroom that support formative assessment (Mathematics Assessment Project, 2013). Teachers use FALs to assess students' understanding of mathematical concepts and use of the Standards for Mathematical Practice. Available for free at the Mathematics Assessment Project through Mathematics Assessment Resource Service, the FALs come in two types: concept development or problem solving lessons. Concept development lessons are meant to reveal students' prior knowledge, develop students' understanding of important mathematical ideas, and connect concepts to other mathematical knowledge (Chauvot & Benson, 2008; Mathematics Assessment Project, 2013; Wilder, 2015).

A key aspect of FALs is to provide students with high quality mathematics tasks. Good mathematics tasks allow students to critique each other's reasoning through rich discussions and conversations. Encouraging students to explain their reasoning, question their learning, and pursue deep understanding are essential in mathematics learning (Butman, 2014; Schoenfeld, 2015). Through FALs, teachers have a tool to support the mathematical shift in instruction to focus on the standards (Phillips & Wong, 2012; Wilder, 2015). FALs also allow students to engage in a productive struggle by encouraging teachers to let students grapple with the mathematics without providing algorithmic methods of solving (Phillips & Wong, 2012). The FAL processes allow teachers and students to focus on the methods and not on getting correct answers (Chauvot & Benson, 2008).

FALs come with their own detailed lesson guide to provide teachers with "the outline of the lesson, suggestions for interpreting student responses, and examples of suitable interventions" (Wilder, 2015, p. 78). For FALs to provide the greatest benefit, the Mathematics Assessment Project (2013) recommends teachers adhere to the lesson guide in presenting the lesson the first few times before making adjustments. They base this recommendation on the lessons being "carefully designed and written as well as trialed in multiple classrooms" (p. 5). They further suggest all students be given the opportunity to attempt the same task and that teachers scaffold support based on the needs of the students. Wilder (2015) also cautions making changes to the structure of the FAL. She claims changes "could negatively affect, or at best, diminish the positive impact of this formative assessment" (p. 82). She further warns of constraints for FALs concerning teacher willingness to implement, accountability, and preparation time.

Technology Use in Classrooms

FALs are written with the intent that they can be utilized by all classrooms, therefore none of the lessons require technology. Mathematics Assessment Project (2013) asserts that the lessons have opportunities for technology and teachers should choose to use the technology appropriately and effectively where available. McKnight et al. (2016) believe that technology use in classrooms enhances collaboration and communication between students and teachers.

According to Evans (2015), districts and schools are less concerned about the technology features and value more how the technology will affect student learning. In their survey of students through Project Tomorrow, students were more interested in how the technology could help with their learning and not as interested in how engaging the technology tools were. Liang, Huang, and Tsai (2012) concluded, from their study of classroom observations where teachers used interactive whiteboards, quality of instructional presentations was improved with board use. However, their results also showed student learning was supported in classroom activities where interactive whiteboards were not used, indicating that board use did not lead to improvement in student achievement (Liang, Huang, & Tsai, 2012).

Research cautions the use of technology as only a presentation tool (Bos, 2009). Bos (2009) declares that technology should be used to explore mathematical relationships. McQuillan, Northcote, and Beamish (2012) suggest interactive whiteboards (IWBs) be used "with pedagogical caution and informed intent" (p. 4). When used improperly, IWBs could create misunderstandings or cause learning difficulties (McQuillan, Northcote, & Beamish, 2012). In their study of IWB use in two primary schools, McQuillan et al. (2012) provided implications for teachers to consider when using IWBs in the classroom. On average, students in their study had a positive view of IWB use in the classroom, claiming they learnt more, participated more frequently, and that work was easier to understand when their teacher used an IWB (McQuillan et al., 2012). Teachers in the study also had some positive attitudes toward IWB use. The teachers felt students were more engaged and motivated when IWBs were used in the classroom, but they sited connection issues and preparation time as factors that interrupted lessons and affected teaching (McQuillan et al., 2012). Shirley and Irving (2015) mentioned students having difficulty with manipulating technology and technology implementation not lining up with teacher practices. Quashie (2009) also reported reliability concerns with technology that students and teachers encountered in a study of IWB use in an all-female secondary school. According to Quashie (2009), IWBs may be inappropriate for some lessons, could be used in ways that render them non-interactive, and are unnecessary to engage and motivate students. The research in support of technology use in classrooms often states the positive effects of enhancing student motivation, engagement, participation, and learning (Eyyam & Yaratan, 2014; McQuillan et al., 2012; Quashie, 2009; Türel & Johnson, 2012; Vassos, 2004;). In Türel and Johnson's (2012) study, they highlight the benefits of the IWB for tactile and visual learners with students being able to touch the board and see different media. Shirley and Irving (2015) found in their study that interactive tools encouraged communication and sharing information between teachers and students instead of only one-way teacher to student transfer. In the research results from Eyyam and Yaratan (2014), students preferred classes that use technology but the students were unsure if the technology helped in their success.

Teacher training is important for effective classroom use of technology. Teachers should be provided training resulting in the ability to utilize the technology on a regular basis and be able train their students on the technology use (Shirley & Irving, 2015). Zbiek (2010) informs about the mixed research messages concerning technology tools in mathematics classrooms and their impact on student learning. In reviewing the literature, Zbiek (2010) found in “studies that compare technology use with nonuse–or that compare alternative technologies–often are comparing, perhaps implicitly, outcomes of substantively different goals and curricula” (p. 40).

CHAPTER III

Methodology

A mixed-methods research design was used in this study due to the benefits of collecting both quantitative and qualitative data (Mertler, 2017). The purpose of this study was to investigate whether a statistical relationship existed between the post-lesson assessment results of students engaging in a formative assessment lesson where the teacher delivers the lesson using technology for the whole class introduction and whole class discussion and students engaging in a formative assessment lesson where the teacher delivers the lesson without using technology for the whole class introduction and whole class discussion. This study also investigated teacher and student perceptions of the use of technology in the teaching and learning of mathematics. Studying these factors can inform teachers whether or not technology use in enacting formative assessment lessons impact student learning.

"Qualitative findings can be used to enhance quality, improve programs, generate deeper insights into the root causes of significant problems, and help prevent problems" (Patton, 2015, p. 205). Surveys were used to allow students to share their thoughts and opinions about the classroom practices and their learning of mathematics content through technology use (Dana & Yendol-Hoppey, 2014). Students were given a platform to express their voices about their preferences for how they best learn mathematics when they use technology and when their mathematics teacher uses technology. When teachers understand different strategies that students attribute to success in mathematics classes, teachers have more information to guide instruction.

Research Questions and Hypotheses

The research questions primary to this study are:

1) Does teacher enactment of a formative assessment lesson using technology for delivery of the whole class introduction and the whole class discussion impact the students' performance on post assessments?

H_0: There is no difference in the performance on post assessments for students participating in a formative assessment lesson enacted with the teacher using technology for delivery of the whole class introduction and the whole class discussion and students participating in a formative assessment lesson enacted without the teacher using technology for delivery of the whole class introduction and the whole class discussion.

2) What implications does the teacher perception of using technology to enact formative assessment lessons have on instruction?

3) What are student perceptions of technology use in instruction delivery of a formative assessment lesson?

Population and Sampling

The sample for this study consisted of eighth grade mathematics students ranging in age from 13 to 16. The sample was taken from the population of students enrolled in a large middle school in the suburb of central Mississippi. The Director of Data Management and Information provided the school and mathematics teacher statistics, which were removed of student identifiers to maintain the integrity of the data. The demographics of the school consisted of 52% male and 48% female students. The races of the students were: White – 68%, Black or African American – 26%, Asian – 1%, Hispanic/Latino – 3%, and Two or More Races – 1%. Twenty-seven percent of the students received free lunch and 7% received lunch at a reduced price.

The data for the sample contained information from 321 eighth grade mathematics students from the school population of 1,258 students. The demographics of the sample consisted of 48% male and 52% female students. The races of the students in the sample were: White – 71%, Black or African American – 25%, Asian – <1%, Hispanic/Latino – 3%, and Two or More Races – <1%.

The three teachers were labeled Teacher A, Teacher B, and Teacher C. The demographic makeup of each teacher's students is shown in Table 1 below.

Table 1

Class Demographics by Teacher (Percents)

Demographic	Teacher A	Teacher B	Teacher C
Female	54	45	48
Male	46	55	52
White	71	69	73
Black/Af. Am.	25	26	24
Asian	0	0	<1
Hispanic/Latino	2	4	2
Two or More Races	1	1	<1

The demographic data for the three teachers' classes was similar to the demographic data for the eighth grade class and the entire school. The final comprehensive benchmark test scores and semester exam scores of the teachers' classes were used to show comparability. Table 2 below shows each teacher's final comprehensive benchmark test class averages by blocks.

Table 2

Final Comprehensive Benchmark Test Scores by Teacher (Percents)

Classes	Teacher A	Teacher B	Teacher C
Experimental A1	54	51	N/A
Experimental A2	56	N/A	49
Experimental A3	N/A	51	50
Experimental A4	53	52	43
Control B5	58	49	53
Control B6	Excluded	47	47
Control B7	N/A	N/A	N/A
Control B8	54	55	45

Table 3 below shows each teacher's semester exam class averages by blocks.

Table 3

Semester Exam Scores by Teacher (Percents)

Classes	Teacher A	Teacher B	Teacher C
Experimental A1	80	78	N/A
Experimental A2	78	N/A	75
Experimental A3	N/A	78	76
Experimental A4	79	76	76
Control B5	80	77	79
Control B6	Excluded	70	76
Control B7	N/A	N/A	N/A

Control B8	78	79	72

The school operated on a block schedule where four 90-minute alternating class blocks were taught each day. The blocks on one day, called A-day, were labeled A1, A2, A3, and A4. The blocks on the next day, called B-day, were labeled B5, B6, B7, and B8. Students attended their mathematics class every other day on an A-day or B-day. Students in the third block on A- or B-day had an additional 30 minutes added to their class block to include a lunch break. All blocks used in the study were regular eighth grade mathematics classes, with Teacher A teaching one class of inclusion students. Inclusion classes include students with disabilities or individualized education programs in the regular classroom setting and an extra teacher to assist during the class. For this study, Teacher A's inclusion class was excluded.

These teachers and participants were chosen out of convenience of the researcher having access to the teachers and their scheduling of formative assessment lessons for their classes. As a matter of convenience, the teachers chose the A-day classes to be their experimental classes and the B-day classes to be their control classes.

Instrumentation

This middle school had been participating in the Southern Regional Education Board's (SREB) Mathematics Design Collaborative (MDC) since 2016, where teachers were using Formative Assessment Lessons (FALs) to engage students in a productive struggle that builds fluency with procedural skills, and deepens mathematical reasoning and understanding (SREB, 2014). FALs are enacted in five phases: 1) Pre-Lesson Assessment 2) Whole Class Introduction 3) Collaborative Activity 4) Whole Class Discussion 5) Post-Lesson Assessment. Students in the experimental and control groups participated in the formative assessment lesson Classifying

Solutions to Systems of Equations. All students completed the pre-lesson assessment (Appendix A), collaborative activity (Appendix B), and post-lesson assessment (Appendix C) under the same conditions. The teachers followed the suggested outline from the Lesson Guide (Appendix D) for implementation of the lessons to ensure enactment consistency across all classes. The Lesson Guide provides teachers with questions they can use as feedback questions to address common issues noticed from the students' pre-lesson assessment work, suggested times for each phase of lesson enactment, questions to ask during the lesson, and sample student responses.

The pre-lesson assessment consists of two questions where students have to answer six exercises completing tables, graphs, and writing explanations. The post-lesson assessment consists of two similar questions with students answering six exercises that have different number values for the same type of questions as the pre-lesson assessment. The collaborative activity requires students to complete six cards, each containing an equation, table, and graph with different pieces of data missing. The activity also contains arrow cards with the choices no solution, infinitely many solutions, or one solution written on them.

The teachers used the students' pre- and post-lesson assessment data to complete the Analyzing Student Data form (Appendix E). The form allowed the teachers to report the number of students scoring a rating from 0 to 3 on each assessment. Teachers also answered questions about the students' misunderstandings. The ratings on the form were as follows: 0 – No responses provided, 1 – Demonstrates little to no understanding, 2 – Demonstrates some understanding, 3 –Demonstrates understanding. The questions had the teachers to identify common issues that they noticed and how they would use the data to inform future instruction.

The researcher observed lessons using SREB's Powerful Mathematics Practices Rubric (Appendix F). The rubric allowed the observer to document teacher and student behaviors using six indicators: 1) Ensuring a Balanced Approach to Mathematics 2) Engaging Students in Assignments that Matter 3) Utilizing Questioning and Feedback for Deeper Understanding 4) Using Formative Assessment Data 5) Fostering a Classroom Environment that Supports Student Ownership of Learning 6) Adapting Teaching and Learning to Re-Engage Students. For this study, the researcher looked for all indicators except the last one, number six.

The teachers were interviewed (Appendix G) to gather their perception of any implications resulting from their use of technology in the formative assessment lesson. The questions that were asked allowed the teachers to provide their views on technology use in general in mathematics and how they were trained and stay abreast of technology developments. All questions for the interview were open response, short answer questions.

Students completed a survey via Google Form (Appendix H) to express their views on the use of technology in a formative assessment lesson delivery. The survey contained 2 yes/no questions, 1 multiple select question, 9 Likert scale questions, and 1 short-answer open response question. For the Likert scale questions, students chose their agreement with each rating: 5 – Strongly Agree, 4 – Agree, 3 – Neutral, 2 – Disagree, 1 – Strongly Disagree. The scale numbers did not give values to the categories for comparisons. The questions asked the students about their perception of technology use in mathematics class and their preferences of how they are taught and learn mathematics as it relates to technology.

Procedure and Time Frame

Eighth grade students at this middle school were enrolled in either a regular mathematics class or a compacted accelerated mathematics class. The students involved in this study were all enrolled in regular mathematics classes during the 2017-2018 school year. This study was conducted during the spring semester over several class periods. For convenience, the three teachers selected their A-day classes to be experimental groups and their B-day classes to be control groups. In the experimental groups, the teacher and students participated in a formative assessment lesson without using any technology. In the control groups, the teacher and students participated in a formative assessment lesson where technology was used. An Interactive Whiteboard, student response system, and laptop computers are the technologies that were used in the lesson.

All students in both the experimental and control groups took the same paper-pencil pre-lesson assessment and post-lesson assessment for the Classifying Solutions to Systems of Equations formative assessment lesson. The pre-lesson assessment was administered to all students during the class period prior to the lesson. Students were given up to 15 minutes to complete the assessment with no assistance from their teacher. Giving the pre-lesson assessment a class period before the lesson allows the teacher time to rate the student papers before the collaborative activity. Due to possible unfair learning opportunities for the control group, the collaborative activity remained the same for both experimental and control groups. The collaborative activity required student groups to complete equations, tables, and graphs on large cards. Placing the cards in a technology software program for students to complete would introduce students to a new technology that could pose a disadvantage for students having to learn to use the technology for the first time during the activity. Also, the control groups would not have normally used technology for the collaborative activity.

Students in both control and experimental groups have had frequent access to a scientific calculator since the school year began. The researcher and teachers decided not to prohibit the use of the calculators during the lesson because all students have been allowed to use them on all assignments. The calculators are also permissible on the end-of-year assessment.

The whole class introduction and whole class discussion took place with the teacher using technology to deliver the lesson for the control groups. The teacher used the Interactive Whiteboard to display prompts and exercises for the students throughout the lesson. The student response system was used for the collection of data from the whole class introduction questions. Volunteer students from the groupings in each class manipulated their results from the collaborative activity on the Interactive Whiteboard to explain and justify their findings to classmates during the whole class discussion.

The whole class introduction and whole class discussion took place without the teacher using technology to deliver the lesson for the experimental groups. The teacher verbalized or wrote on a large dry-erase board to provide all instructions, exercises, and prompts for the students. Students wrote their responses on mini dry-erase boards and held them up to show the teacher. Groups displayed their results on a poster created from the collaborative activity to explain their results to the class. All of the formative assessment lessons are written for usability in all mathematics classrooms; therefore, none of the lessons require technology to implement.

All students were administered a paper-pencil post-lesson assessment following the whole class discussion. Students completed both the pre- and post-lesson assessments individually with no teacher assistance. The teachers rated each student's assessment with a score from 0 to 3. The teacher used the data from the assessments to complete the Analyzing Student Data form. Each student's pre and post paper were labeled as pre or post and a student number to maintain anonymity from the researcher. The researcher observer was present in one experimental class and one control class for each of the three teachers for the lesson delivery. The researcher also takes on the role of MDC district coach and would normally observe the lesson and participate in assisting the teacher with the lesson delivery. To maintain the integrity of the study, the researcher only observed and did not assist during the lessons.

A debrief was held during the teacher's planning block after all classes had experienced the formative assessment lesson. During the debrief, the teachers participated in a face-to-face interview individually to answer questions about their perceptions of technology use, training on technology, and student learning implications from technology use. The interviews were recorded to help with verbatim transcription later.

The students completed a survey after participating in the lesson to provide their views of technology use in mathematics class. Students returning a consent form were provided a link through email or a Learning Management System to take the survey. The teachers allowed the students to complete the 10-minute survey during a class block following the lesson enactment.

Analysis Plan

For comparing the blocks of all three teachers simultaneously, an analysis of variance (ANOVA) test was used. According to Mertler (2017), when comparing the data of more than two groups it is appropriate to analyze the data using an ANOVA test. ANOVA tests were conducted on the semester averages and the final comprehensive benchmark test results of each class to determine if the class blocks were similar groups. Unpaired-sample t-tests using students' pre-lesson assessment rating scores were conducted to determine if a statistical significant difference existed between students' pre-lesson assessment rating scores from the experimental groups and the control groups. Unpaired-sample t-tests or independent-measures t-tests are used when comparing two groups, one treatment and one control, using a common dependent variable, such as assessment scores (Mertler, 2017). Paired-sample t-tests were used to compare data between the blocks of each teacher. When the same group is compared based on a pretest and a posttest, the measures are compared using a paired-sample t-test or a repeated-measures t-test (Mertler, 2017). In groups that were not similar, the researcher looked for patterns of growth from pre-lesson assessment to post-lesson assessment. Unpaired-sample t-tests using students' post-lesson assessment rating scores were conducted to determine if a statistical significant difference exists between students' post-lesson assessment rating scores from the experimental groups and the control groups. Paired-sample t-tests were used to compare data between the blocks of each teacher. Because the data collected was categorical, chi-square tests were performed on the pre- and post-lesson assessment results and Likert scale student survey responses to determine p-values. Chi-square tests are appropriate to use on data that have frequency counts within a category (Mertler, 2017). The critical alpha level for p-value statistical analyses was set at 0.05. Coding was used to analyze the qualitative data to find important patterns and themes that were useful in reporting the findings of the research (Mertler, 2017). The students' survey results were coded into tables to address the key factors. Patterns were coded from the responses presented by the teachers' interview questions.

Validity and Reliability

The FAL components were reviewed by the teachers and based on their evaluation of the items, the items were representative of the content they were teaching. Each teacher checked the questions on the lesson assessments and agreed that they measured the intended content. The teachers met to calibrate their ratings for scoring the students' pre- and post-lesson assessments to ensure consistency. The teachers and researcher reviewed the student survey questions to check for grade-level language appropriateness and clarity. SREB MDC coaches and representatives observed mathematics lessons in this district and calibrated their ratings for the Powerful Mathematics Practices Rubric to ensure measurement of the intended teacher practices.

Each teacher administered the pre- and post-lesson assessments to their own students under the same conditions. The findings of this study may be generalizable to the middle school population for eighth grade given that a large percentage of the school's eighth grade student population was used in the study. The results of this study will answer the research questions posed.

Limitations and Scope

This study has many limitations and delimitations. The teachers' years of experience may have influenced their pedagogical beliefs and strategies in how lessons were delivered to each class block. One of the teachers expressed concern with using one class in particular that contained all of her inclusion students. Inclusion students receive additional services with another teacher during the instructional day and the inclusion teacher is also present and assisting during the class period. Each of the three teachers was at a different stage of MDC training. The training that they have received through MDC and the number of FALs they have had the opportunity to enact may be critical in determining the effectiveness of lesson delivery. Table 4 below provides the teachers' background in teaching experience, MDC participation, and FAL enactments.

Table 4

Teacher Background Experience

Category	Teacher A	Teacher B	Teacher C
Teaching (years)	14	1	5
MDC Participation (years)	2	1	3
FAL Enactments (count)	4	5	2

The number of potential participants for the survey was reduced due to parents who refused to allow their student to participate in the survey and due to the students who declined to participate. The interviews and surveys were subject to sampling and measurement error. The students that choose to participate in the survey may have exhibited similar characteristics, beliefs, and practices. The role of the researcher as the district MDC coach could have played a role in effecting the data. The responsibility of the coach to program commitments could have caused some bias in the observation of the lessons. The teachers' insufficient knowledge, experience, and attitudes about the technology would be another bias to consider. Teachers' beliefs may have been incongruent with the instruction observed by the researcher. The teachers' responses to the interview questions may not have been completely objective. The teacher's identity was not anonymous to the researcher; therefore, the teachers' responses may have reflected what they believe the researcher approves. It was out of the scope of this research study for the researcher to observe every class participating in the study. Some classes were taking place simultaneously. The study was delimited to only the eighth grade class in one middle school in a district with multiple schools of various size eighth grade mathematics populations. To avoid data distortion from students present for only one of the assessments, students present for only the pre-lesson assessment or present for only the post-lesson assessment were not included in the study. The student survey could have contained confusing, misleading, or unclear questions that may have influenced responses. The data does not include all possible answers to all the questions because no questions were marked as required. The survey was delivered electronically and respondents were not given an opportunity to seek clarity on items or terms unfamiliar to them. To avoid this delimitation, the researcher attempted to use language that was familiar to middle grades students. The teachers also reviewed the survey and provided feedback on what they thought might be any misunderstanding of wording. Two questions were adjusted as a result of the feedback. The FAL chosen was not a FAL that the collaborative activity could also be delivered using technology. Only select groups of students were allowed to present their findings to the class.

CHAPTER IV

Results

The purpose of this mixed-methods research study was to investigate whether a statistical relationship exists between the post-assessment results of students engaging in a formative assessment lesson where the teacher delivers the lesson using technology for the whole class introduction and whole class discussion and students engaging in a formative assessment lesson where the teacher delivers the lesson without using technology for the whole class introduction and whole class discussion. This study also allowed for teacher and student perceptions of the use of technology in the teaching and learning of mathematics. The questions primary to this research were:

1) Does teacher enactment of a formative assessment lesson using technology for delivery of the whole class introduction and the whole class discussion impact the students' performance on post assessments?

> H_0: There is no difference in the performance on post assessments for students participating in a formative assessment lesson enacted with the teacher using technology for delivery of the whole class introduction and the whole class discussion and students participating in a formative assessment lesson enacted without the teacher using technology for delivery of the whole class introduction and the whole class discussion.

2) What implications does the teacher perception of using technology to enact formative assessment lessons have on instruction?

3) What are student perceptions of technology use in instruction delivery of a formative assessment lesson?

This study began with the researcher looking for eighth grade mathematics classrooms that were participating in the Mathematics Design Collaborative (MDC), where the teachers are required to implement formative assessment lessons in their classrooms. Three 8th grade mathematics teachers at a large suburban middle school in central Mississippi agreed to include their classes in this research study. The data for the sample of 321 eighth grade mathematics students in this study were taken from the school population of 346 eighth grade students enrolled in standard mathematics. Twenty-five students in Teacher A's inclusion class were excluded from the study.

Students were participants in a formative assessment lesson, which included a pre-lesson assessment and a post-lesson assessment administered on two different days in the study. Only students present for both the pre- and post-lesson assessments were included in the tests conducted on the data. Of the 321 possible student participants from the three teachers' seventeen blocks of standard mathematics, 244 students were present for both the pre- and post-lesson assessments.

The first tests were conducted to determine if the classes for all three teachers were academically matched. ANOVA tests were run on the first semester averages and the final comprehensive benchmark test scores for the three teachers' students to determine if there were statistically significant differences between the classes. The results can be found in Table 5 below.

Table 5

Teacher Classes Comparison

	df	*F*	*n*	*p*
Benchmark	2	8.35	17	.0041
Semester Avg	2	2.8	17	.0949

Note. Teacher A has an inclusion class that is not included in the study.
*$p < .05$

According to the results of the ANOVA tests, there were no statistically significant differences between any of the groups for the students' first semester averages ($p = .0949$). The students' final comprehensive benchmark test scores ANOVA results showed no statistically significant differences between the means of Teacher A classes and Teacher B classes and no statistically significant differences between the means of Teacher B classes and Teacher C classes, but there was a statistically significant difference between the means of Teacher A and Teacher C classes ($p = .0041$) at the level $p < .01$ according to the Tukey HSD test.

The teachers implemented the phases of the formative assessment lesson. Each teacher administered the pre-lesson assessment and the post-lesson assessment to all the students in their A-day classes, which were the experimental (non-tech) groups, and to all the students in their B-day classes, which were the control (tech) groups. The pre-lesson assessment was given before the collaborative activity and the post-lesson assessment was given after the collaborative activity. The descriptive statistics for the pre- and post-lesson assessment scores for each teacher for the experimental and control classes are provided below in Table 6.

Table 6

Students Pre- and Post-Lesson Assessment Scores Descriptive Statistics by Class per Teacher

Teacher	*n*	*M*	*SD*
Non-tech classes			
A			
Pre	45	1.02	0.78
Post	45	1.73	0.72
B			
Pre	37	0.78	0.82
Post	37	1.32	0.88
C			
Pre	50	1.06	0.62
Post	50	1.48	0.68
Tech classes			
A			
Pre	27	1.00	0.78
Post	27	1.70	0.82
B			
Pre	42	0.57	0.63
Post	42	1.29	0.92
C			
Pre	43	0.98	0.41
Post	43	1.40	0.62

Because the pre- to post-lesson assessment scores would not be of interest to investigate considering the prediction of increase in scores, the researcher wanted to answer the research question: Does teacher enactment of a formative assessment lesson using technology for delivery of the whole class introduction and the whole class discussion impact the students' performance on post assessments? The results of the teacher ratings for the students' pre- and post-lesson assessments are presented in Table 7 below along with their p-values calculated from a chi-square test.

Table 7

Summary of Students' Pre- and Post-Lesson Assessment Data (Total Number of Students Per Category)

	No responses provided	Demonstrates little to no understanding	Demonstrated some understanding	Demonstrated understanding	p-value
Teacher A - Class 1A Non-tech					
Pre	0	6	6	0	0.0074
Post	0	4	5	3	0.1979
Teacher A - Class 2A Non-tech					
Pre	7	9	2	1	0.0242
Post	0	6	10	3	0.0092
Teacher A - Class 4A Non-tech					
Pre	5	6	3	0	0.1116
Post	0	9	4	1	0.0029
Teacher A - Class 5B Tech					
Pre	2	6	5	1	0.1826
Post	1	2	7	4	0.1116
Teacher A - Class 8B Tech					
Pre	5	8	0	0	0.0024
Post	0	9	3	1	0.0018
Teacher B - Class 1A Non-Tech					
Pre	5	7	1	0	0.0179
Post	1	5	5	2	0.2699
Teacher B - Class 3A Non-Tech					
Pre	6	6	1	2	0.1367
Post	4	7	3	1	0.1718
Teacher B - Class 4A Non-Tech					
Pre	4	4	1	0	0.1290
Post	1	5	2	1	0.1888
Teacher B - Class 5B Tech					
Pre	3	5	2	0	0.1577
Post	0	4	4	2	0.2214
Teacher B - Class 6B Tech					
Pre	11	6	0	0	0.0002
Post	5	8	4	0	0.0525
Teacher B - Class 8B Tech					
Pre	7	7	1	0	0.0097

Post	3	7	2	3	0.2688
Teacher C - Class 2A Non-Tech					
Pre	4	13	2	1	0.0004
Post	0	13	3	4	0.0003
Teacher C - Class 3A Non-Tech					
Pre	3	13	1	0	0.0000
Post	0	10	7	0	0.0004
Teacher C - Class 4A Non-Tech					
Pre	0	8	5	0	0.0024
Post	0	8	4	1	0.0077
Teacher C - Class 5B Tech					
Pre	1	13	1	0	0.0000
Post	0	9	4	2	0.0076
Teacher C - Class 6B Tech					
Pre	1	16	0	0	0.0000
Post	0	11	5	1	0.0005
Teacher C - Class 8B Tech					
Pre	2	7	2	0	0.0210
Post	0	9	2	0	0.0002

$*p < .05$

According to the p-values, one non-tech class for Teacher A showed no statistically significant difference in the students post assessment scores ($p = .1979$), while the other two classes did show a statistically significant difference ($p = .0092$, $p = .0029$). Teacher A's two tech classes showed a statistically significant difference in the scores for one class ($p = .1116$) and no statistically significant difference in the scores for the other class ($p = .0018$). All of the six classes for Teacher B, whether they were tech or non-tech, showed no statistically significant difference for any of the post lesson assessment scores. All of the six classes for Teacher C, whether they were tech or non-tech, showed a statistically significant difference in the post lesson assessment scores. All p-values were based on a critical alpha level of $p < .05$. Due to mixed results of the quantitative tests finding some statistically significant differences in the data, the null hypothesis is rejected.

Although the quantitative data provides an answer to the quantitative research question, the researcher wanted to include qualitative data to investigate the teacher and student perceptions of using technology in mathematics lessons. The three teachers participated in a face-to-face interview to ask them questions about their frequency with using technology to present lessons, advantages and disadvantages of using technology, student learning impact from technology use, background in technology training, and thoughts concerning the formative assessment lesson enactments with and without using technology. Each teacher was interviewed separately after all class enactments of the formative assessment lesson had taken place. Their responses were audio recorded for transcription accuracy. The researcher read through each teacher's response to each interview question and highlighted, in one color, the common phrases in the responses for all three teachers and highlighted, in a different color, the common phrases in the responses for two of the three teachers. Common themes were coded from the interview transcripts to answer the research question: What implications does the teacher perception of using technology to enact formative assessment lessons have on instruction?

The specific interview questions that addressed the research question were: 4) What are some advantages and disadvantages for you using technology in math lesson presentation? 5) What are some advantages and disadvantages for your students using technology to participate in a math lesson? 6) What, if anything, have you observed in student learning from using technology? 10) Are there any thoughts you want to share about your enactments of the formative assessment lessons using technology versus not using technology?

Teacher A Interview Questions Responses

Question 4: What are some advantages and disadvantages for you using technology in math lesson presentation? "I find that lessons run a little smoother with technology." Teacher A also responded that she felt using traditional whiteboards only allowed so much information to be shown to students at one time. She elaborated on the convenience of being able to "flip back" to something on the interactive whiteboard so students could see it again. Another advantage Teacher A reported was, "I can record it right there as I'm working it." She further asserted that the recorded videos, which are stored in their LMS for student access, are accessible to students anytime throughout the year. The primary disadvantage that Teacher A mentioned was being prepared with a backup plan for any unexpected technical issues with using technology.

Question 5: What are some advantages and disadvantages for your students using technology to participate in a math lesson? "I find that my students these days are digital natives, so they're so embedded in technology all the time whether it's their cell phone or their computer. I feel like it speaks their language almost, if you deal with technology because it just all makes sense to them." Teacher A also commented that she feels students are bored with lessons where they are not entertained with technology. She also said that she and the other teachers have tried to include movement to break the monotony of students sitting in one place working on the computer all day long. Teacher A did not mention any disadvantages for students using technology to participate in a math lesson.

Question 6: What, if anything, have you observed in student learning from using technology? "I think technology allows students to be more organized." Teacher A elaborated thoroughly about how her students, especially absent ones, know to check the LMS site for what occurred in class each day. She said her students are able to stay better organized and on track with the class even when they are absent due to everything for the class being electronically organized.

Question 10: Are there any thoughts you want to share about your enactments of the formative assessment lessons using technology versus not using technology? “I will say that I found that the day I used technology the class, the lesson seemed to run smoother and we got further on that day than I did the previous day. The day, the other day, it took two days.” Teacher A also felt the lesson seemed easier for the students on the day she used technology. “I also liked the technology day where at the end when we were sharing our matches that we all made, uh it was easier for the kids to go the board and show the whole class rather than having their individual posters.” Teacher A also mentioned that when she looked at her students pre- and post-lesson assessment papers, she thought the results were about the same. “I did not see where one day the kids seemed to have an advantage over the other, that they all seemed to make a lot of the same connections and a lot…we had… the conversations were very similar.”

Teacher B Interview Questions Responses

Question 4: What are some advantages and disadvantages for you using technology in math lesson presentation? “For me it’s an easy source.” Teacher B expressed the same advantage as Teacher A about the convenience of not having to rewrite problems every class because of the display ability of the interactive whiteboard. She also added that she felt her students made connections quicker from seeing the problems on the board. When asked about disadvantages, Teacher B responded, “Oh yeah, I think that some disadvantages to technology sometimes it feels a little bit impersonal.” She mentioned parents not seeing technology as an advantage due to the “impersonal value” of it. Another advantage she mentioned that was the same as Teacher A, was the ability to upload the notes from class to the LMS for student access.

Question 5: What are some advantages and disadvantages for your students using technology to participate in a math lesson? “For students the advantages are, well that’s how their state test is gonna look. It's gonna be on the computer." Teacher B thought students needed exposure to using the computer as much as possible to help them prepare for their state assessment. She also felt an electronic state test was a disadvantage for students. "I think that sometimes some of those great connections are lost because, a, a lot of math you need to really be able to visualize and see and conceptualize and before we get to the computer, I would like to see that done by hand."

Question 6: What, if anything, have you observed in student learning from using technology? "Well if you go back to the different types of learners, you got auditory learners and oral learners and visual learners, I think that it definitely reaches a lot of people because it's very haptic." Teacher B further elaborated that, "I have seen the student who I don't necessarily think would have succeeded if they hadn't had the technology." She emphasized again the advantage of her students having access to the lessons and being able to look at them again at home. Similar to Teacher A, Teacher B mentioned her students knowing how to do so much more on technology than she knows how to do. She also felt that students' interest in learning how to use technology and exploring it is important.

Question 10: Are there any thoughts you want to share about your enactments of the formative assessment lessons using technology versus not using technology? "It was, it was the, the lesson itself went smoother, faster, and I think that the kids understood a little bit more when I had technology." Teacher B felt there were "hiccups" with the instructions that could have been avoided if the technology was used in all classes. She felt that the inability to display the instructions on the board for the students might have been an issue. She agreed with Teacher A that the discourse between the classes was the same whether she used technology or not. She further agreed with Teacher A that the student results display on the technology day was better.

“On the technology day, we were able to manipulate all of these different pieces on the board and I thought that was really good because a group could go up and manipulate and then the others could, uh, see exactly what they were doing.”

Teacher C Interview Questions Responses

Question 4: What are some advantages and disadvantages for you using technology in math lesson presentation? “I like the bell work online or on Nspire cause it shows the results.” Teacher C liked the convenience of using technology in lesson delivery, which was the consensus of the other two teachers as well. Teacher C did not comment on the disadvantages of using technology in math lesson presentation.

Question 5: What are some advantages and disadvantages for your students using technology to participate in a math lesson? “I have a problem with kids like, if it’s on the computer, then their just gonna rely on the calculator and computer, they don’t even think about getting paper out. But if you gave it to them on paper, their gonna try to write stuff down so there’s an advantage of it makes it quicker, I guess.” Teacher C explained how students are discouraged from writing anything down or showing their work on paper because they are using the computer. He also talked about how he has not experienced any technical discipline with students “getting on different stuff” when they should be working on something else.

Question 6: What, if anything, have you observed in student learning from using technology? “I don’t know if I have an exact answer to that question because we hadn’t utilized bell work on paper and that’s really the main way that we use it, so I don’t know if I have a measure.” Teacher C explained that they used technology as more of a routine for the beginning of the lessons, but had not used an alternative other than technology to be able to compare or see how technology might influence student learning.

Question 10: Are there any thoughts you want to share about your enactments of the formative assessment lessons using technology versus not using technology? “The…using the technology in the second day of the lesson, the B-day, was much more efficient. I know the first day it wasn’t smooth as the second day.” Teacher C felt the students working on their mini whiteboards on the non-technology day took more time. He also mentioned, as Teacher A and Teacher B, the final student displays of the results from the collaborative activity was better on the technology day. “It just made it easier where you could manipulate and see all the connections at once instead of just gluing them on a poster where the kids couldn’t see it real well.”

Table 8 below is a summary of the teachers’ interview results, which shows the commonalities in the teachers’ responses.

Table 8

Teachers’ Interview Results Summary

Teacher A	**Teacher B**	**Teacher C**
Backup Plan	State Test	Discourages Paper Use
Videotape Lessons	Impersonal	Engage Students Quicker
Pre/Post No Difference	By Hand Before Technology	Hindered Without
Meet Different Learning Styles		
Canvas Upload for Student Access Later		
Student Know More Than Teacher About Using Technology		
Good Discourse With or Without Technology		

	Directions Better Displayed with Technology
	Bell work Only Use for Technology
Use Technology Everyday	
Students Like Using Technology	
District Trained Through Professional Development	
Presentations Better With Technology	
Lesson Flow Smoother With Technology	
Quicker Lesson With Technology	

Student Survey Results

Another qualitative research question asked to gather more data to investigate the student perceptions of using technology in mathematics lessons was: What are student perceptions of technology use in instruction delivery of a formative assessment lesson? From this question, the researcher designed a survey that the teachers could administer to their classes after the formative assessment lesson enactments. The purpose of the survey was to give students a voice to express their thoughts on the role technology plays in their learning in mathematics class. The survey was delivered via an email link to a Google form for each student who returned a signed parent and student permission form to participate. The survey contained 2 yes/no questions, 1 multiple select question, 9 Likert scale questions with response choices ranging from Strongly Disagree to Strongly Agree, and 1 short-answer open response question.

The first two yes/no questions asked the students if they were present for the specific formative assessment lesson enacted in the second semester of 2018 and if they returned a signed permission form to participate in the survey. The purpose of these two questions was to ensure only students with permission were taking the survey and to determine the number of students who were taking the survey, but were not present for the formative assessment lesson. One hundred twenty-three of the 131 students taking the survey responded that they were present for the lesson, 7 students responded that they were not present for the lesson, and 1 student did not provide a response to the question.

The third survey question asked students to indicate which technologies they had experienced in their mathematics classes. The researcher was interested in knowing which technology resources the students had experienced. The online software application category provided examples for the students to know which types of applications the researcher was meaning and to distinguish between the online software used for homework assignments. The category "other" was included for students to provide any technology resource that was not included in the list. Only one student selected other and provided the response math videos from YouTube. Table 9 below provides the number and the percentage of students responding to question 3.

Table 9

Technologies Experienced in Mathematics Class

Technology	# of respondents	percent
Interactive Whiteboard	114	87
Student Response System	129	98
Laptop Computer	119	91
Online Software Application	100	76
Online Homework Program	127	97
Document Camera	40	31
Other	1	1

[a] n = 131

The Likert scale questions that were included in the survey asked students about their preferences for learning in mathematics class. Table 10 below provides the percentage of student responses to each category and the p-value for each question's results.

Table 10

Student Survey Likert Scale Responses (Percents)

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*	*p-value*
Q4. I like when my teacher uses technology to teach a math lesson.	2	2	21	45	31	0.0000
Q5. I like when I use technology to participate in a math lesson.	3	8	23	35	31	0.0000
Q6. I learn better when my math teacher uses technology to teach a lesson.	3	8	27	35	27	0.0000
Q7. I learn better when I use technology in a math lesson.	5	11	32	27	25	0.0000
Q8. I prefer to have paper copies of work in math class.	11	17	18	22	31	0.0064
Q9. I prefer to work hands-on with manipulatives in math class.	4	6	32	26	32	0.0000
Q10. I prefer to submit my work online than to turn in my work on paper.	15	11	31	19	24	0.0040
Q11. I am more successful in math class when my teacher uses	2	10	39	30	20	0.0000

technology.						
Q12. I am more successful in math class when I use technology.	2	12	37	32	17	0.0000

[a] n = 131 [b] Question 7 includes responses for 130 respondents; one student did not answer Q7.
*p < .05

The very small p-values for each Likert scale question in the student survey indicates that there are statistically significant differences in the responses. On all but three questions, more than 50% of the students chose 4 or 5, agree or strongly agree respectively, for their response. Question number 11 had exactly 50% of the students choosing 4 or 5. Questions number 10 and 12 had less than 50% of the students choosing 4 or 5 as their response.

The last question on the survey was the open response question asking students to provide any additional views that they had about technology use in their math class. Fifty students provided additional comments. The researcher read through the comments and highlighted common responses. The reoccurring themes and student assertions are compiled in Table 11 below.

Table 11

Student Survey Themes

Themes/Student Assertions	Number of students
Paper-pencil is better than technology	15
Math is easier with technology	7
Prefer to show work/steps on paper	5
Learning is better with technology	12
Technology is limited or limits math	4

The 5 students that responded to the theme preferring to show their work or steps on paper overlap with the 15 students that responded to the theme paper-pencil is better than technology and gave some of the following comments:

"I'd rather take summatives on paper rather than online."

"I like to be able to write examples on paper."

"It's easier to have a paper copy of the work sheet or test and work out problems on it."

"I feel like I do better on quizzes and summatives when I do them on paper."

"I do like using paper copies in math class so I can see how I worked it."

"It also is hard to do math problems on the computer because you can't work things out."

Although 12 students responded they learn better in mathematics with technology, there was 1 student who responded, "I don't believe that I learn better/worse when using technology." The other respondents did not address how technology influenced their learning. Student responses that addressed the theme of technology being limited or limiting mathematics provided the following comments:

"For work like math, I would prefer to have a more hands-on experience, and I feel technology is limiting this."

"When we do use it, it is very limited."

"Technology is good but it can get in the way of class sometimes."

Two of the students responding to the theme that math is easier with technology also responded that they learn better with technology. Another response from the remaining students in the theme math is easier with technology commented, "It is easier for teachers to teach and visibly show students different things."

Teacher Observations

Observations of one experimental class and one control class took place during the formative assessment lessons for each teacher. The researcher completed 5 of the 6 indicators from the SREB Powerful Mathematics Practices Rubric for each teacher. The indicators relevant to the research questions were: Indicator 2) Engaging Students in Assignments that Matter, Indicator 3) Utilizing Questioning and Feedback for Deeper Understanding, Indicator 4) Using Formative Assessment Data, and Indicator 5) Fostering a Classroom Environment that Supports Student Ownership of Learning. The results of the chi-square test performed at a critical alpha level of $p < .05$ to determine the p-values for the rubric results are presented in Table 12 below.

Table 12

Teacher Observation Rubric Ratings Results

	Experimental classes p-value	*Control classes p-value*
Indicator 2 Standard 1	0.8013	0.8013
Indicator 2 Standard 2	0.2998	0.2998
Indicator 2 Standard 3	0.2998	0.2998
Indicator 3 Standard 1	0.8013	0.2998
Indicator 3 Standard 2	0.8013	0.2998
Indicator 3 Standard 3	0.8013	0.2998
Indicator 3 Standard 4	0.2998	0.2998
Indicator 3 Standard 5	0.2998	0.2998
Indicator 4 Standard 1	0.2998	0.0293
Indicator 4 Standard 2	0.8013	0.2998
Indicator 4 Standard 3	0.2998	0.2998

Indicator 5 Standard 1	0.2998	0.0293
Indicator 5 Standard 2	0.0293	0.0293
Indicator 5 Standard 3	0.2998	0.2998

*p < .05

One indicator standard for an experimental class showed a statistically significant difference (p = .0293), whereas all the remaining indicator standards for experimental classes showed no statistically significant difference. Three indicator standards for control classes showed a statistically significant difference (p = .0293), whereas the remaining indicator standards for control classes showed no statistically significant difference.

CHAPTER V

Discussion

Summary

This research study investigated the impact of using technology in the delivery of a formative assessment lesson on student performance on the post-lesson assessments in eighth grade mathematics classrooms. The results of this study sought to indicate if a teacher using an interactive whiteboard and student response system for the presentation of the whole class introduction and students using technology for the presentation of the whole class discussion make a difference in post-lesson assessment performance compared to classes where neither the teacher nor students used any technology. Each of the three eighth grade math teachers in this study enacted one formative assessment lesson that consisted of five phases: 1) Pre-Lesson Assessment 2) Whole Class Introduction 3) Collaborative Activity 4) Whole Class Discussion 5) Post-Lesson Assessment. Students in seventeen classes, where nine classes were experimental (non-tech) groups and eight classes were control (tech) groups, participated in the formative assessment lesson Classifying Solutions to Systems of Equations. The teachers also participated in a one-on-one interview to gather information on their perceptions of the use of technology in mathematics lesson delivery. The students participated in a survey to gather information on their perceptions of how technology impacts their learning in mathematics class. The researcher also observed each teacher during one experimental class and one control class to gather anecdotal information to complement the research study.

The quantitative data results of this research study were mixed in determining whether the use of technology in the delivery of phases of a formative assessment lesson had an impact on students' post-lesson assessment performance. The post-lesson assessment student rating scores for some teachers' experimental (non-tech) and control (tech) classes showed the use of technology having an impact and other non-tech and tech classes showed no impact from technology use. Teacher A's results indicated that for some classes there was a difference enough to attribute technology impacted the difference, but some classes did not show a difference. Teacher B's results indicated that technology did not have an impact and Teacher C's results indicated technology did have an impact.

The teachers commented during their interviews that they felt the days when technology was used allowed the lessons to flow smoother and the lessons went faster. They also felt their students liked using technology. Some of the advantages they provided for using technology included convenience for presenting content, ability to record lessons, and ability to provide resources electronically to students. Some of the disadvantages they provided for using technology in math lessons were technical issues, students encouraged not to write down anything, and the technology use being impersonal.

Students responded in the survey to multiple select, open response, and Likert scale questions. Their results indicated that they have used a variety of technologies in their mathematics classes. They also reported mixed preferences for using technology and using pencil and paper.

The teacher observations were rated using a rubric of indicators and standards for Powerful Mathematics Practices. The indicator standards focused on assignments that the teachers administered, strategies that the teachers used in implementation, and actions the teachers took based on the data they collected.

Implications of Results from Quantitative Data

The mixed quantitative results did not conclusively indicate that technology use in formative assessment lessons impacted student performance on post-lesson assessments. These results implicate that more research is necessary.

Implications of Results from Teacher Interviews

The teachers all agreed in their interview responses that the lesson enacted on the days with technology flowed smoother and faster. Although the teachers were convinced technology use made lesson presentation easier, they did not indicate that using technology impacted their students' learning. Two teachers indicated their student conversations seemed to be similar regardless of the use of technology. This information speculates that technology use does not make a difference in the student discourse that takes place.

Implications of Results from Student Surveys

The student survey results were inconclusive as well to determine if technology use in a formative assessment lesson impacts student learning. More than 50% of the students taking the survey indicated a fondness for technology use and credited technology with better learning in mathematics, but less than 50% attributed technology use to their success in mathematics. This result implicates students may be unsure as to whether the use of technology impacts their learning.

Implications of Results from Teacher Observations

The teacher observation rubric results provided the least evidence for technology use impacting student performance on post-lesson assessments. The results suggested teachers selected quality assignments, used the formative assessment data to inform instruction, and used appropriate formative assessment strategies with their students. The rubric results did not indicate the use of technology in the lesson and therefore could not be used to determine if technology had an impact on student learning.

Overall Implications

The overall implications of this research study indicate that teachers using technology in the delivery of a formative assessment lesson will not impact student learning. Teachers may use technology in a lesson to meet the needs of students who believe the use of technology helps them learn better and easier in mathematics. Teachers may also use technology if they feel more comfortable presenting a lesson with technology. Students may prefer to use technology, but teachers should not expect the students' performance to be impacted if they use technology.

Relevance to Literature Review

The researcher began the study with a concern as to whether the use of technology had an impact on student performance because the school district in the study has invested in supplying the mathematics classrooms with a wealth of technology resources. The theoretical position of the researcher was in support of the technology having an impact on student learning based on the abundance of technology available for use in mathematics teaching. Based on the teachers' selection of classes for experimental and control, the interview responses, and the student survey responses, the teachers and students seemed to expect technology to have a positive impact on student performance.

The teachers were given the autonomy to choose which classes they wanted as experimental and which classes they wanted as control. The teachers unanimously decided to implement the lesson to their experimental classes first and all on the same day. Reflection on the lesson from the previous day is inevitable and the teachers would naturally think about things that could have been done differently to improve the lesson the next time it is taught. By waiting until the next day, which happened to be on a Monday after a weekend, to enact the lesson to the control groups, the teachers had days to think about the things they wanted to change. The researcher was intentional in a conversation with each teacher before the control group enactments to remind them to stay as close as possible to the same way the enactment took place for the experimental groups. The teachers agreed not to make any changes except the necessary ones for enacting the lesson with technology. The control and experimental groups that were observed seemed to be enacted with the same fidelity.

The teacher interview responses indicated that they thought the student discourse and conversations were about the same in both the experimental and control groups. This assertion is not in agreement with the literature. McKnight et al. (2016) believe that technology use in classrooms enhances collaboration and communication between students and teachers. The teachers' belief that the use of an interactive whiteboard enhanced the quality of their instructional presentation does agree with Liang, Huang, and Tsai (2012) who concluded, from their study of classroom observations where teachers used interactive whiteboards, quality of instructional presentations was improved with board use.

Research cautions about using technology as only a presentation tool (Bos, 2009). Bos (2009) declares that technology should be used to explore mathematical relationships. In this research study the teachers and students only used the interactive whiteboard and student response system as presentation tools. McQuillan, Northcote, and Beamish (2012) suggest interactive whiteboards (IWBs) be used "with pedagogical caution and informed intent" (p. 4). When used improperly, IWBs could create misunderstandings or cause learning difficulties (McQuillan, Northcote, & Beamish, 2012). Despite these cautions from research, the teachers in this study felt their use of interactive whiteboards provided advantages for their students.

In their study of IWB use in two primary schools, McQuillan et al. (2012) provided implications for teachers to consider when using IWBs in the classroom. On average, students in their study had a positive view of IWB use in the classroom, claiming they learnt more, participated more frequently, and that work was easier to understand when their teacher used an IWB (McQuillan et al., 2012). The student survey responses for this research study concur with the literature's claim of learning more and work being easier to understand. More than 50% of the students responded with agree or strongly agree to better learning when they used technology and the teacher used technology. In the additional comments, students reported mathematics being easier with the use of technology.

Teachers in a study from the literature review felt students were more engaged and motivated when IWBs were used in the classroom, but they sited connection issues and preparation time as factors that interrupted lessons and affected teaching (McQuillan et al., 2012). One of the teachers in this study also sited technical issues as a disadvantage to using technology. None of the teachers in this study indicated they thought their students were more engaged or motivated with the use of the interactive whiteboard. According to Quashie (2009), IWBs may be inappropriate for some lessons, could be used in ways that render them non-interactive, and are unnecessary to engage and motivate students.

The research in support of technology use in classrooms often states the positive effects of enhancing student motivation, engagement, participation, and learning (Eyyam & Yaratan, 2014; McQuillan et al., 2012; Quashie, 2009; Türel & Johnson, 2012; Vassos, 2004;). In Türel and Johnson's (2012) study, they highlight the benefits of the IWB for tactile and visual learners with students being able to touch the board and see different media. Teacher B is the only teacher in this study who mentioned learning styles. She indicated feeling the learning styles of her students were better met with the use of technology.

In the research results from Eyyam and Yaratan (2014), students preferred classes that use technology but the students were unsure if the technology helped in their success. The student survey results in this study indicated that more than 50% agreed or strongly agreed to liking when the teacher used technology and when they used technology in mathematics lessons. One student provided an additional response that they did not believe they learned better or worse when using technology. The two survey questions asking whether students thought they were more successful when their teacher used technology or when they used technology did not receive more than 50% of the students in agreement. This result indicates that students may be unsure as to whether technology impacts their learning in mathematics. Zbiek (2010) informs about the mixed research messages concerning technology tools in mathematics classrooms and their impact on student learning. In reviewing the literature, Zbiek (2010) found in "studies that compare technology use with nonuse–or that compare alternative technologies–often are comparing, perhaps implicitly, outcomes of substantively different goals and curricula" (p. 40).

Limitations

There were limitations that arose during this study that were not considered before the study began. The instruments in the study were the sources for most of the limitations. The interview protocol, student survey, and observation rubric were designed to provide conclusive evidence to answer the research questions, but their results revealed flaws in their construction.

The teacher interview questions included many generic questions related to technology and only one question about the implementation of the formative assessment lesson. The teachers answered questions about their technology training and how they use technology in their everyday lessons, which was helpful in understanding their perceptions of technology. However, the one question about formative assessment lesson implementation did not focus on specific aspects of the lesson where technology was used. The teacher responses to the question provided more comparison of the experimental classes day to the control classes day instead of their opinion of the role technology played in student learning. Specific questions to address this topic should have been part of the interview protocol.

The student survey questions were generic as well to gather information about their perceptions of technology use. More specific questions to address the students' thoughts on their learning through technology use would have better addressed the research questions. All students with permission, whether they were in the experimental or control group, took the survey and all of their results were gathered in one list. The results were not divided into two groups to have the results of students in the experimental group separate from the results of students in the control group. Knowing what students in each group thought about technology use could have provided distinguishing factors if the experimental group did not believe the same as the control group.

The observation rubric indicated teacher implementation of best practices but the use of technology use was not explicitly stated in the rubric indicators. No mention of technology made it difficult to relate the rubric results as answers to the research questions. The rubric indicators were focused on the value of the lesson content and actions of the teacher and students, which limited the observer in rating differently from experimental to control classes. Most teacher ratings remained the same for both experimental and control groups.

The teachers implementing only one formative assessment lesson to their classes was a limitation for the study. A variety of formative assessment lessons are available for eighth grade math, but the short time of the study allowed the teachers to implement only one lesson. This particular lesson was a concept development lesson, but there are also problem solving lessons. Teachers implementing more than one of both kinds of lessons could indicate whether technology impacts both concept development and problem solving lessons.

Another limitation of the study is using the word technology and not specifying the actual technology resource and how it would be used. In this study, the use of technology only includes the teachers and students using interactive whiteboards and student response systems. The teachers and students were not using the technology as devices to aid in learning, only as presentation tools.

Recommendations for Future Research

This study was worthwhile to investigate the use of technology in formative assessment lesson enactment for insight to ways teachers can modify lessons with technology and uses of the interactive whiteboard in lesson presentations for teachers and students. Data was collected from the pre- and post-lesson assessments to indicate whether technology use during the formative assessment lesson impacted student learning. More data would need to be collected through multiple trials to determine if technology use in formative assessment lessons has an impact on student learning. This study included the implementation of one formative assessment lesson at one middle school. A study involving more teachers at various middle schools enacting more than one formative assessment lesson over time would be better for investigating whether technology use for presentations has an impact on students' post lesson assessment performance. Specifics about the actual technology used and its purpose to increase student learning would be better suited for a study of technology's impact on student learning.

The limitations of this study revealed implications for future research that include modifying the interview protocol, student survey, and teacher observation rubric. Instruments designed to gather specific data related to the research questions instead of generic information are recommended. Interview protocol questions could include questions about the actual technology used and how it might impact student learning. The student survey could have questions to address student preferences about specific technology use and have choices to select from that are not limited to a range between agree and disagree. An observation rubric with indicators specific to rating teachers on the technology being used and how students interact with the technology is recommended.

School districts, especially the one in this study, have spent large amounts of money to equip classrooms with technology resources. The presence of technology does not indicate that teachers are utilizing it with fidelity. Using technology does not indicate that it is impacting student learning. The results of this study may raise questions of whether technology purchases are worth the investment. The implications from this research indicate that technology use in a formative assessment lesson does not necessarily impact student learning.

CHAPTER VI

Addendum: Informal Further Study

In the original research, the investigation studied the use of technology by eighth grade mathematics teachers during enactment of a Formative Assessment Lesson (FAL). The teachers used the interactive whiteboard primarily as a presentation tool during the whole class introduction and the whole class discussion of the lesson for the control groups. The teachers used a student response system to send questions to the student devices and to collect their responses to the questions. The teachers did not use the interactive whiteboard or the student response system in the experimental groups. Students completed a pre-lesson assessment before participating in a collaborative activity and completed a post-lesson assessment after the collaborative activity. The study sought to find whether technology use during parts of the lesson impacted the students' performance on the post-lesson assessment. The study results were mixed and did not determine whether or not the use of technology had an impact on student performance on the post-lesson assessment. One of the implications for future research was to be more specific about the types of technology and how it was used. Based on this implication, a look into the teacher's background and training with technology and an investigation into implications from observing peers' use of technology were selected for this study. Because the teachers had never officially observed one another, even though they plan all their lessons together, an observation component was considered. The teachers' lesson deliveries in the observations during the original project were vastly different. Seeing such varied strategies prompted a wonder for whether or not the teachers discussed teaching methods or modeled any of the lessons during their planning time. These implications and curiosities led to a study of the following research questions:

1) What are the implications of teacher peer observations during mathematics lessons when looking for peer use of technology?

2) What impact does teacher peer observations during mathematics lessons have on lesson delivery for the observer?

3) What role does a teacher's technology background and training play in technology use during lessons in eighth grade mathematics classrooms?

A research plan was developed to include reviewing the interview questions and results about technology background and training from the previous study, teacher observations of each other with the researcher, and a debrief session with the three teachers. Table 13 below indicates the blocks that the teachers observed their colleagues with the researcher. The peer observations took place on A-day, October 24, 2018.

Table 13

Class Observation Schedule by Teacher

Teacher A	**Teacher B**	**Teacher C**
Planning Block - 3A	Planning Block - 2A	Planning Block - 1A
1st half of block 3A – Observes Teacher B	1st half of block 2A – Observes Teacher C	1st half of block 1A – Observes Teacher A
2nd half of block 3A – Observes Teacher C	2nd half of block 2A – Observes Teacher A	2nd half of block 1A – Observes Teacher B
Common Planning Block - 4B		

The format of the observations allowed the researcher to see a beginning of the block and an ending of the block for each teacher. During the observations, the researcher took field notes while each teacher completed a form to document their Look Fors and Evidence (Appendix P).

Each teacher observed their peer's use of technology and chose an additional Look For that they wanted feedback on. An additional Look Fors list was provided to the teachers that included the following items:

- Feedback
- Student equity
- Wait time
- Learning goals/intentions
- Student-centered classroom
- Culture/climate safe for student mistakes
- Mathematical discourse
- Standards for Mathematical Practice
- Formative assessment
- Differentiation

The additional Look For selected by each teacher is listed below:

- Use of Technology - All
- Teacher A – Wait Time
- Teacher B – Questioning
- Teacher C – Questioning

After the observations, the researcher allowed each teacher time to process what they had observed from their peers and an opportunity to incorporate some of the strategies they had seen by waiting a week before debriefing with the teachers. A week after the observations occurred, the researcher revisited the teachers during their common planning block to debrief from the observations the previous week. During the debriefing, a series of questions were asked for the teachers to provide reflections and feedback.

For this study, the researcher began with revisiting the interview questions from the previous study. Two questions asked about the teachers' technology background and training: Question 7 - How have you been trained to use the technologies that are present in your lessons? Question 9 - As more technologies are developed, how do you learn about new technologies to use in math?

The Interview

7) How have you been trained to use the technologies that are present in your lessons?

Teacher A

Teacher A is the most experienced of the three teachers with fourteen years of teaching experience before the research study began. Teacher A used an interactive whiteboard and a student response system in the lesson. For the Smart interactive whiteboard, Teacher A replied that she simply dove in and started playing with the board until she figured out how it worked. She says that her district provided some formal training on the student response system.

Teacher B

Teacher B is the least experienced of the three teachers with one year of teaching experience prior to the original research study. Teacher B also used an interactive whiteboard and student response system in the lesson. Teacher B started using Smart technology when she was in high school. During a teacher mentor program her senior year, she was allowed to create lessons using the technology. After she graduated from high school, she did not use the technology again until she started her teaching career. There was little to no training offered, but she asked questions and experienced trial and error while becoming familiar with the technology again. She also commented as Teacher A did that she received some training from the district on the student response system.

Teacher C

Teacher C had five years of teaching experience prior to participating in the research study. Although Teacher C did not mention the technology used in the lesson, he spoke about professional development training provided by his school district, where he attended during the summer and when curriculum specialists provided training at his school during planning blocks. He commented that the best training was when he was allowed to participate in the training as a student.

9) As more technologies are developed, how do you learn about new technologies to use in math?

Teacher A

Following blogs, reading message boards, and going to training were the primary ways Teacher A responded that she learns about new technologies in math. Teacher A also learns about new technologies from attending conferences, which is where she saw a document camera being used for the first time. Participation in a study for Harvard introduced her to the swivel, which she used with a tablet to videotape her class. To know how to use the products she said, "I just read the instruction manual and figured out how to use it." Exposure to technology through seeing other teachers use it in their classes prompts Teacher A to think of ways to adapt the technology to use in her classes.

Teacher B

A focus on technology through math classes in college was how Teacher B learned about new technologies. She also has had administrators to inform her of new technologies. Even though Teacher B says she does not seek out technology as much as she used to, she is not opposed to asking about new technology if she is not finding it through workshops and training.

Teacher C

Teacher C credits professional development, online resources, and administrators with informing him of new technologies. He also learns about new technology from talking with other teachers in his building.

All three teachers talked about how they had been trained through professional development from their district. The table below captures the teachers' responses to the interview questions about their technology background and training.

Table 14

Teacher Interview Responses for Technology Questions

<table>
<tr><th>Teacher A</th><th>Teacher B</th><th>Teacher C</th></tr>
<tr><td>Blogs/Message Boards</td><td>College</td><td>Planning Block/Summer Training</td></tr>
<tr><td>Participating in Studies</td><td>Mentor Teacher</td><td>Websites/Online Resources</td></tr>
<tr><td>Observing Other Classes</td><td>Requests Training</td><td>Talking to Colleagues</td></tr>
<tr><td colspan="2">Trial and Error</td><td>Participating as Student</td></tr>
<tr><td colspan="2">Conferences/Workshops</td><td></td></tr>
<tr><td></td><td colspan="2">Administrator Notification</td></tr>
<tr><td colspan="3">Student Response System Training</td></tr>
</table>

Interactive Whiteboard Technology Access
District Professional Development

After revisiting the technology questions from the first study, the researcher scheduled peer observations with the teachers. As each of the teachers observed their colleagues they completed an Observation Look Fors and Evidence sheet. The first Look For that each teacher observed was his or her colleagues' use of technology.

The Observations

Table 15 below captures a summary of the results for each teacher from their peer's Observation Look For and Evidence Form.

Table 15

Teacher Observation Look For and Evidence Form Results

Teacher A	**Teacher B**	**Teacher C**
Use of interactive whiteboard/calculators		Use of timer and document camera
Software used as motivational tool	Posed questions for students to self-assess	Modeled bell work
Inconsistent with wait time	Repeated student answers to questions	Class discussion before revealing correct answers
Modeled bell work	Asked open, less formal, but leading questions	Suggest asking about process when students are incorrect

Teacher C

Teacher C was the first of the three teachers to participate in the observations. Teacher C and the researcher observed Teacher A during the first half of first block. Teacher C documented observing student response software and calculators being used by the students in Teacher A's class for bell work. He also noted how Teacher A was using the software as a motivation tool with the students trying to earn the highest possible percentage as a class. He mentioned the teacher was using the student responses to formally assess and correct incomplete student responses. In the second Look For chosen by Teacher A, wait time, Teacher C noticed the intentionality of Teacher A. She was being deliberate about waiting for students to respond to questions. Teacher A was not consistent with her wait time and Teacher C wrote in his documentation that she interrupted one student and finished his response for him.

The second half of first block, Teacher C observed Teacher B. He documented the use of the interactive whiteboard and calculators for the Use of Technology Look For. More scripting was included for the second Look For, questioning. Teacher C noted that Teacher B posed questions that students could ask himself or herself to check their work. He also recorded that Teacher B repeated the student answers when they replied to her questions.

Teacher B

The second block round of observations took place with Teacher B observing Teacher C the first half of the block and observing Teacher A the remaining half of the block. Teacher B noticed how the student response software was being used during bell work for students to input their answer choices. She also recorded that there was a computer in the back of the room being used as a timer and she noted the teacher's use of a document camera. Teacher B found it interesting that Teacher C was modeling the bell work for his students and he was reviewing the student answers at the end of the conversation. He allowed his students to vote on the answers and participate in classroom discussion before he would reveal the correct answers. Teacher C also chose questioning as his second Look For. Teacher B listed the questions of interest that she heard Teacher C ask, but she did not elaborate or provide any other details about his questioning.

During the second half of second block as Teacher B was observing Teacher A, she noticed how the teacher used her interactive whiteboard technology to manipulate what students could and could not see on the board. Parts of a problem were revealed at different times as the teacher wanted students to discuss. She noted that Teacher A also modeled the bell work for her students. In observing wait time, Teacher A's second Look For, Teacher B documented that Teacher A would ask a question and then wait for students to figure out on their own. Teacher B also said Teacher A had great opening questions.

Teacher A

Teacher A, who had fourteen years of teaching experience, took far fewer notes on her form for her two observations than did the other two teachers, Teacher B with one year of teaching experience and Teacher C with five years of teaching experience. For use of technology, Teacher A noted bell work, feedback, and slides during her observation of Teacher B in the first half of third block. Teacher A did not provide details of how the listed items related to the teacher's use of technology. In looking for questioning, she noticed Teacher B asking open, less formal, but leading questions of her students.

In looking for the same two Look Fors in Teacher C's class in the second half of third block, Teacher A recorded slides were being used with the technology. When observing questioning, Teacher A offered suggestions on the form for Teacher B. She wrote Teacher B should offer an illustration with the questions and ask about the process when students are wrong.

After all the observations took place, the researcher scheduled a debrief session with all three teachers in attendance. During the debrief three questions were asked for the teachers to provide responses. Teacher A spoke first most often when the questions were asked. Teacher A is the most experienced of the three teachers and her responses to the questions may have influenced her peers' responses.

The Debrief

Question 1: Were there any adjustments that you made to your lessons after you observed your peers?

Each teacher opened the lesson with the same bell work; however, the presentation of the opener was left to each teacher's discretion. Teacher C used a geometric model of a cube as a manipulative for one of the questions that assessed volume. After the other two teachers observed his class, Teacher A did not make any adjustments to her lessons because her physical cube was not easily accessible, but Teacher B pulled her model cube out of a closet to use for demonstration with her remaining classes. During the debrief, Teacher A commented, "All the time we were talking about volume that's a perfect time to have that physical model out ready to show them this is what we're talking about."

Teacher C noticed the way Teacher A used the technology to present her bell work and even though he liked the way she used the technology to make the answer review process more efficient, he did not make the adjustment in his bell work presentation. Teacher C said, "I like how you collected it, then you asked them what the answers were, then you went over it. And then you went back and reviewed the responses." He also felt that Teacher A was using the student response technology as more of a motivation tool for her students. Teacher B was curious and asked Teacher A to explain her process because she did not get to observe the opener for

Teacher A. After Teacher A explained her process, Teacher B also discovered that Teacher A and Teacher C modeled the process of what students should have on their papers by using a blank notebook page on their interactive whiteboards to write down the answers to the questions so students would know what they should have written in their notes for notebook checks. The teachers also discussed the amount of time they each allowed students to work on the bell work. Teacher B added, "I don't know if I could start immediately doing it that way cause the way that I do bell work right now is very different from both of ya'lls. Both of you model…and I don't."

Teacher A talked about how Teacher B seemed to go over her bell work much faster. She mentioned a concern of how much more time it could take if Teacher B did change and add the modeling component. Teacher B admitted to not knowing enough about the student response system software to review her bell work the same as the other two teachers. She asked about training and Teacher A offered to help by inviting her to come observe when she would be using the software. Another adjustment that was made by Teacher B was, "I reworded how I asked some of my questions based on the way that you did [Teacher A]."

Question 2: Were there some strategies or methods that you saw that might influence what you may do for future lessons?

Teacher B liked the way Teacher C questioned his students. She appreciated how he focused his questions to repeatedly address the content. The teachers also discussed ideas for creating flash cards to help students with recalling concepts and creating posters to focus on the vocabulary. Calculator use was also discussed and the teachers strayed a little off task to talk about rational numbers. The teachers mentioned very few strategies that they thought would influence what they might do for future lessons.

Question 3: What are some reflections on the process of observing one another?

All three teachers seemed to like the process of observing one another. Teacher A commented, “I like seeing how you might say something different or you might question something different.” Teacher C talked about how they each think of things at a moment’s notice, but they do not think to share the changes with their colleagues. Observing each other would give them an opportunity to see how each makes adjustments in their lessons from what they discuss in their planning meetings. Teacher C said, “There is stuff we do every single lesson that we don’t think about, we just adjust.” Teacher A suggested they plan to observe each other once every unit and choose a focus that they would give each other feedback about.

Conclusion

All three teachers noticed in their peer observations which technologies were being utilized and how each technology was being used with the students. In most cases, each teacher documented how the other two teachers may have used the technology differently than how he or she was using the technology. After the observations, one teacher made adjustments to her lessons the same day and the other two teachers had plans to update their lessons in the future based on what they observed. All three teachers expressed an interest during the debrief to observe one another more often to see how each presents his or her lesson with the technology and to provide their colleagues with feedback. When one of the teachers would alter his or her lesson from what they discussed during their common planning, the changes would not always be communicated to the other two teachers. Through an observation, the teachers would be able to see the adjustments for themselves.

In the original research study, the results were mixed in determining whether or not technology use for lesson delivery in a Formative Assessment Lesson impacted student performance on the post-lesson assessment. In this informal study of technology used during lessons that were not Formative Assessment Lessons, the researcher was looking for implications from teacher observations of their peers' use of technology. The qualitative data collected indicated that each teacher found at least one aspect of their peer's use of technology that influenced his or her lesson delivery in their remaining classes that day or for future classes. The implications of the peer observations indicate the teachers appreciated the process and had an interest in observing each other in the future.

Peer observations proved to be an important aspect of informing teacher practice in this research study. As the teachers in this study observed their peers, they noted changes they could make in their own lesson delivery and adapted their teaching to include those changes. Because of this influence in peer observations, the researcher plans to continue investigating the implications of peer observations in the future.

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List of Appendices

Working with Linear Equations

A

x	-3	2	3
y	-3	7	9

B

x	0	2	4
y	5	7	9

C

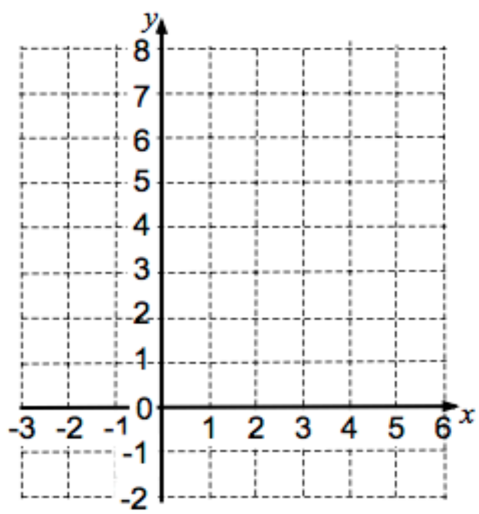
x	-1	0	2
y	5	1	7

D

x	-1	0	2
y	1	3	7

1a. Which of these tables of values satisfy the equation $y = 2x + 3$? Explain how you checked.

b. By completing the table of values, draw the lines $y = 2x + 3$ and $x = 1 - 2y$ on the grid.



$y = 2x + 3$

x	-2	0	
y			5

$x = 1 - 2y$

x	0		5
y		0	

c. Do the equations $y = 2x + 3$ and $x = 1 - 2y$ have one common solution, no common solutions, or infinitely many common solutions? Explain how you know.

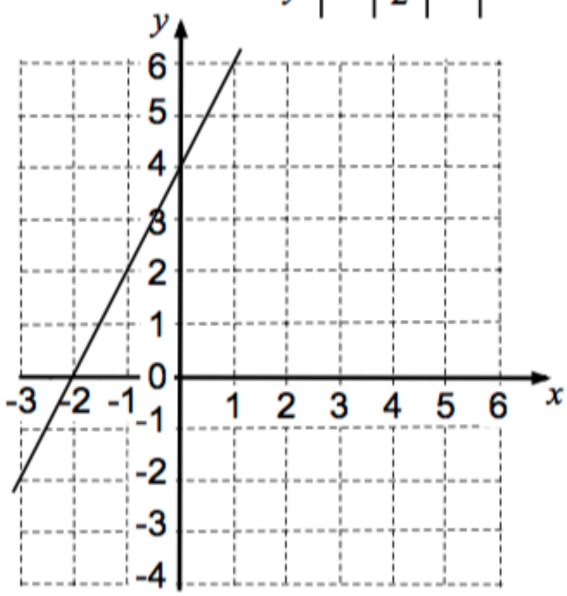
2. Draw a straight line on the grid that has no common solutions with the line $y = 2x + 3$.
What is the equation of your new line? Explain your answer.

Card Set A: Equations, Tables & Graphs

C1

$y =$ ______

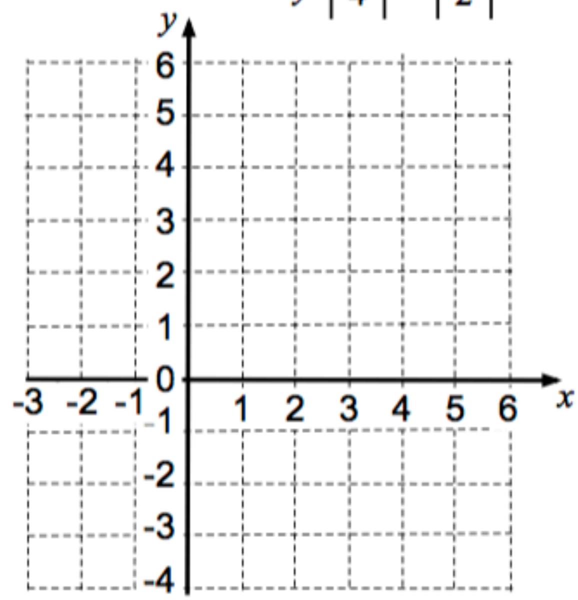
x	-3		1
y		2	



C2

$x + 2y = 8$

x	0	2	
y	4		2

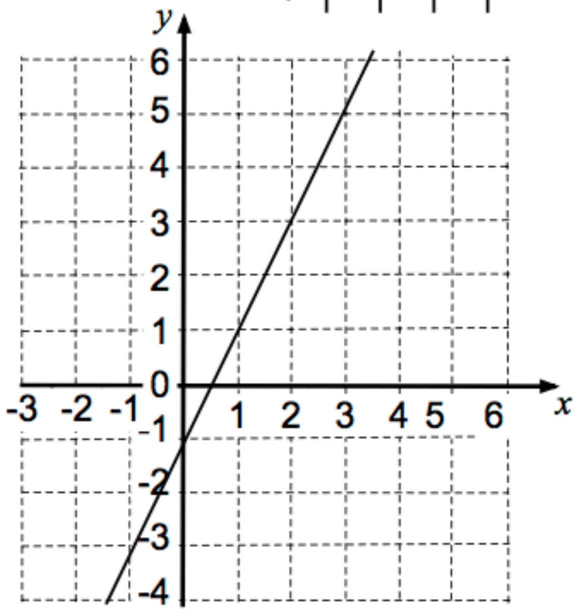


Card Set A: Equations, Tables & Graphs (continued)

C3

$y =$ _______

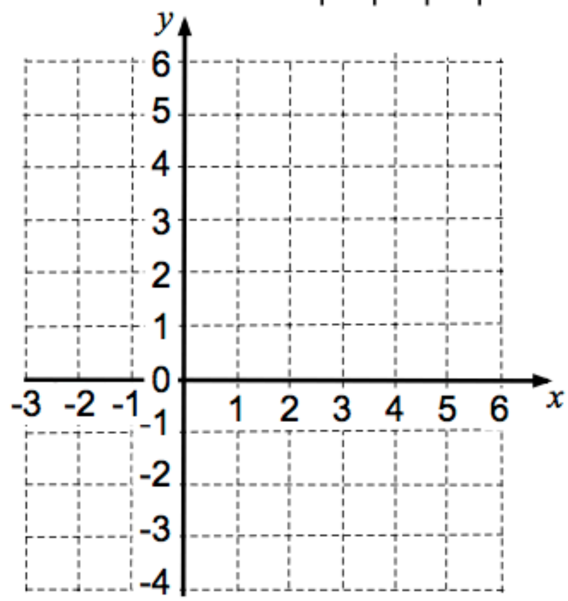
x	0		3
y	-1	3	



C4

$y = 2(x + 2)$

x		-2	
y	-2		6

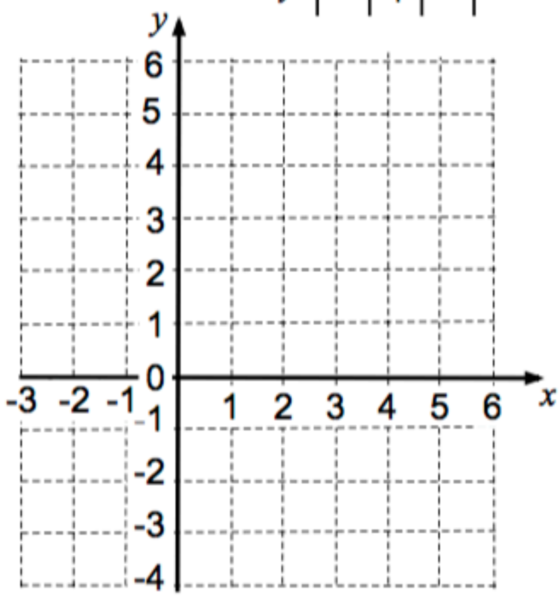


Card Set A: Equations, Tables & Graphs (continued 2)

C5

$y = -\frac{1}{2}x + 4$

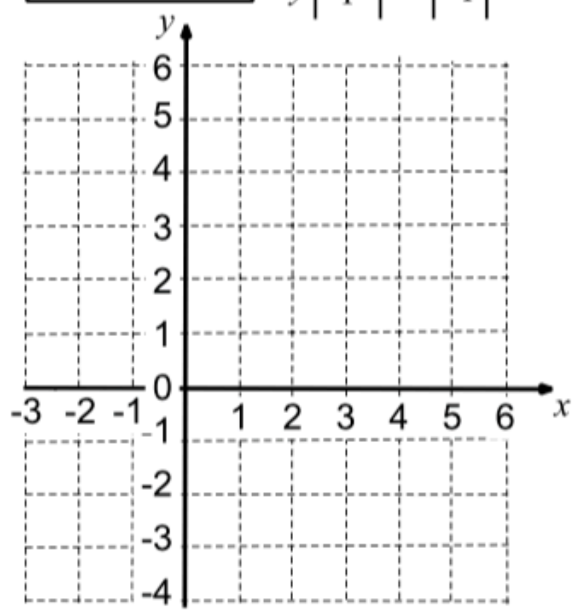
x	-2		6
y		4	



C6

$x = \frac{1}{2} - 2y$

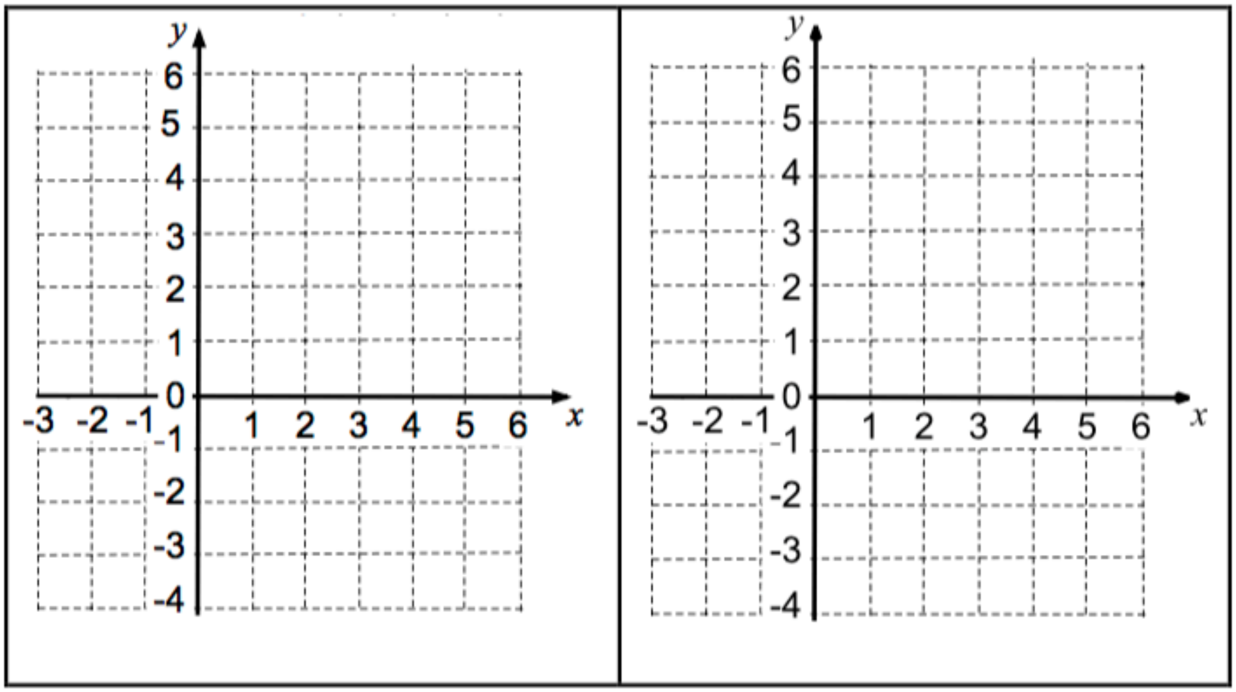
x		0	
y	1		-1



Card Set B: Arrows

No common solutions	No common solutions	Infinitely many common solutions	Infinitely many common solutions
One common solution when x = ___ , y = ___	One common solution when x = ___ , y = ___	One common solution when x = ___ , y = ___	One common solution when x = ___ , y = ___
One common solution when x = ___ , y = ___	One common solution when x = ___ , y = ___	One common solution when x = ___ , y = ___	One common solution when x = ___ , y = ___

Graph Transparency



Working with Linear Equations (revisited)

A

x	0	1	2
y	4	4	5

B

x	1	2	3
y	4	6	8

C

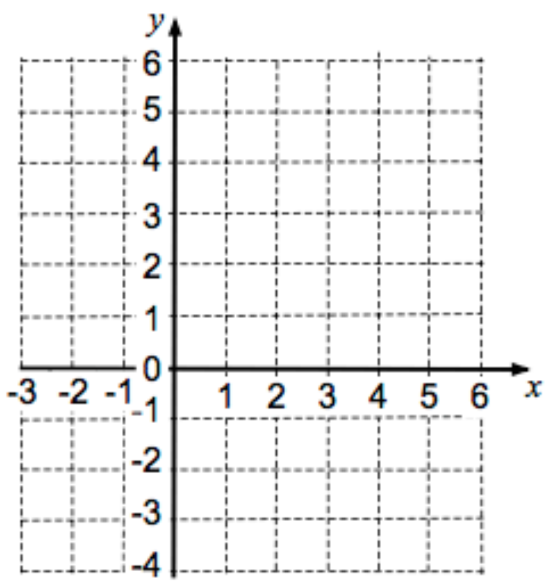
x	-2	-1	1
y	-5	-2	4

D

x	-2	-1	1
y	-2	0	4

1a. Which of these tables of values satisfy the equation $y = 2x + 2$? Explain how you checked.

b. By completing the table of values, draw the lines $y = 2x + 2$ and $x = 4 - 2y$ on the grid.



$y = 2x + 2$

x	-3	0	
y			6

$x = 4 - 2y$

x		4	6
y	1		

c. Do the equations y = 2x + 2 and x = 4 – 2y have one common solution, no common solutions, or infinitely many common solutions? Explain how you know.

2. Draw a straight line on the grid that has no common solutions with the line $y = 2x + 2$. What is the equation of your new line? Explain your answer.

SUGGESTED LESSON OUTLINE

Whole-class introduction (10 minutes)

Give each student a mini-whiteboard, pen, and eraser. Maximize participation in the discussion by asking all students to show you solutions on their mini-whiteboards.

Write the equation $y = 3x + 2$ on the board.

Ask the following questions in turn:

If x = 5 what does y equal? [17]

Ask students to explain how they arrived at their answer. If a variety of values are given within the class, discuss any common mistakes and explore different strategies.

If x = -1 what does y equal? [-1]

If students are struggling with multiplying by a negative number, ask the class to summarize the results of multiplying with positives and negatives. Some students may believe that because x and y are different letters, they have to take different values. Point out that here both x and y can both be equal to -1.

If y = 8 what does x equal? [2]

If y = 0 what does x equal? [-⅔]

Students may either use guess and check or rearrange the equation in order to figure out the value for x. You may want to discuss these two strategies.

Students often think that they have made a mistake when they get an answer that is not a whole number. Discuss the value of checking an answer by substituting it back in as x, as well as emphasizing that not all solutions will be positive integers and that negative and fractional solutions can also occur.

It may also be appropriate to discuss the benefits of leaving answers in fraction form rather than converting to a decimal, especially when a recurring decimal will result. Provide an example of say, ½, and discuss the difference between this fraction expressed as a decimal, and -⅔ expressed as a decimal, in terms of accuracy and rounding.

How can you check your answer? [By substituting it back in as x.]

How can you check that all your answers are correct? [Sketch the coordinates on a grid and see if they form a straight line.]

If students' work on the assessment task has highlighted issues with plotting points and making connections between solutions to a linear equation and points on a straight line graph, it may be appropriate to ask students to check that the solutions for the equation $y = 3x + 2$ form a straight line when plotted.

Explain to students that in the next activity they will be using their skills of substitution and solving equations to help them to investigate graphical representations of linear equations.

Collaborative activity: *Card Set A: Equations, Tables & Graphs* (20 minutes)

Organize students into pairs.

For each pair provide a cut up copy of *Card Set A: Equations, Tables & Graphs* and some plain paper.

These six cards each include a linear equation, a table of values and a graph. However, some of the information is missing.

In your pairs, share the cards between you and spend a few minutes, individually, completing them. You may need to do some calculations to complete the cards. Do these on the plain paper and be prepared to explain your method to your partner.

Once you have had a go at filling in the cards on your own, take turns to explain your work to your partner. Your partner should check your cards and challenge you if they disagree. It is important that you both understand and agree on the answers for each card.

When completing the graphs, take care to plot points carefully and make sure that the graph fills the grid in the same way as it does on Cards C1 and C3.

Slide P-1: *Card set A: Equations, Tables, Graphs* on the projector resource summarizes these instructions.

If students are struggling, suggest that they focus on Cards C4 and C5 first.

It does not matter if students are unable to complete all six cards. It is more important that they can confidently explain their strategies and have a thorough understanding of the skills they are using.

For students who complete all the cards successfully and need an extension, ask them to spend a few minutes comparing their completed cards:

Select two cards and note on your whiteboards any common properties of the equations and/or the graphs. Repeat this for all of your completed cards. This will help you later.

While students work in small groups you have two tasks: to make a note of students approaches to the task, and to support student reasoning.

Note student approaches to the task

Listen and watch students carefully and note any common mistakes. For example, are students misinterpreting the slope and intercept on cards where the graph has already been drawn? Do they fail to recognize an equation/graph that has a negative gradient? You may want to use the questions in the *Common issues* table to help address misconceptions.

Also notice the way in which students complete the cards. Do students use the completed table of values to plot the graph or do they use their knowledge of slope and intercept to draw the graph directly from the equation? Do students first plot the line using easy values for x or y, and then read off values from the graph in order to complete the table? Do students rearrange the equation or do they use guess and check to solve for x or y? Do students use multiplication to eliminate the fraction from the equation? Do students use the slope and intercept or guess and check to figure out the equation of the graph?

You will be able to use this information in the whole-class discussion.

Support student reasoning

Try not to make suggestions that move students towards a particular strategy. Instead, ask questions to help students to reason together.

Martha completed this card. Jordan, can you explain Martha's work?

Show me a different method from your partner's to check their method is correct.

If you find the student is unable to answer this question, ask them to discuss the work further. Explain that you will return in a few minutes to ask a similar question.

How can you check the card is correct? [Read off coordinates from the line, use the slope and intercept to check the equation matches the line, etc.]

For each card, encourage students to explain their reasoning and methods carefully.

How do you know that $y = 3$ when $x = 2$ in Card C2? What method did you use?

How did you find the missing equation on Card C1/C3? Show me a different method.

Suppose you multiply out the equation on Card C4. What information can you then deduce about the graph? [The y-intercept and slope.]

Which of these equations is arranged in a way that makes it easy to draw a graph using information about the line's y-intercept and slope? [C5.] What are they? [4 and -½.]

You may find some students struggle when the slope of a line is negative or when dealing with negative signs, or when the slope is a fraction.

Checking work (15 minutes)

Ask students to exchange their completed cards with another pair of students.

Carefully check the cards and point out any answers you think are incorrect.

You must give a reason why you think the card is incorrect but do not make changes to the card.

Once students have checked another group's cards, they need to review their own cards taking into account comments from their peers and make any necessary changes.

Extending the lesson over two days

If you are taking two days to complete the unit then you may want to end the first lesson here. At the start of the second day, briefly remind students of their previous work before moving on to the next collaborative activity.

Collaborative activity: Using *Card Set B* to link *Card Set A* (20 minutes)

Give each pair two copies of *Card Set B: Arrows* (already cut-up), a copy of *Graph Transparency*, a transparency pen, a large sheet of paper for making a poster, and a glue stick.

Choose two of your completed cards from Card Set A *and stick them on your poster paper with a gap in between.*

You are going to try and link these cards with one of the arrows.

The cards will either have no common solutions, one common solution or infinitely many common solutions. Select the appropriate arrow and stick it on your poster between the two cards. If the cards have one common solution, you will need to complete the arrow with the values of x and y where this solution occurs.

Add another completed card to your poster and compare it with the two already stuck down. Find arrows that link this third card with the other two and stick the cards down.

Continue to compare all the cards in this way, making as many links as possible. If some of the cards are incomplete, you will need to complete them before comparing them.

Slide P-2: *Card set B: Arrows* on the projector resource summarizes these instructions.

Some students might find it helpful to use a transparency when comparing the cards.

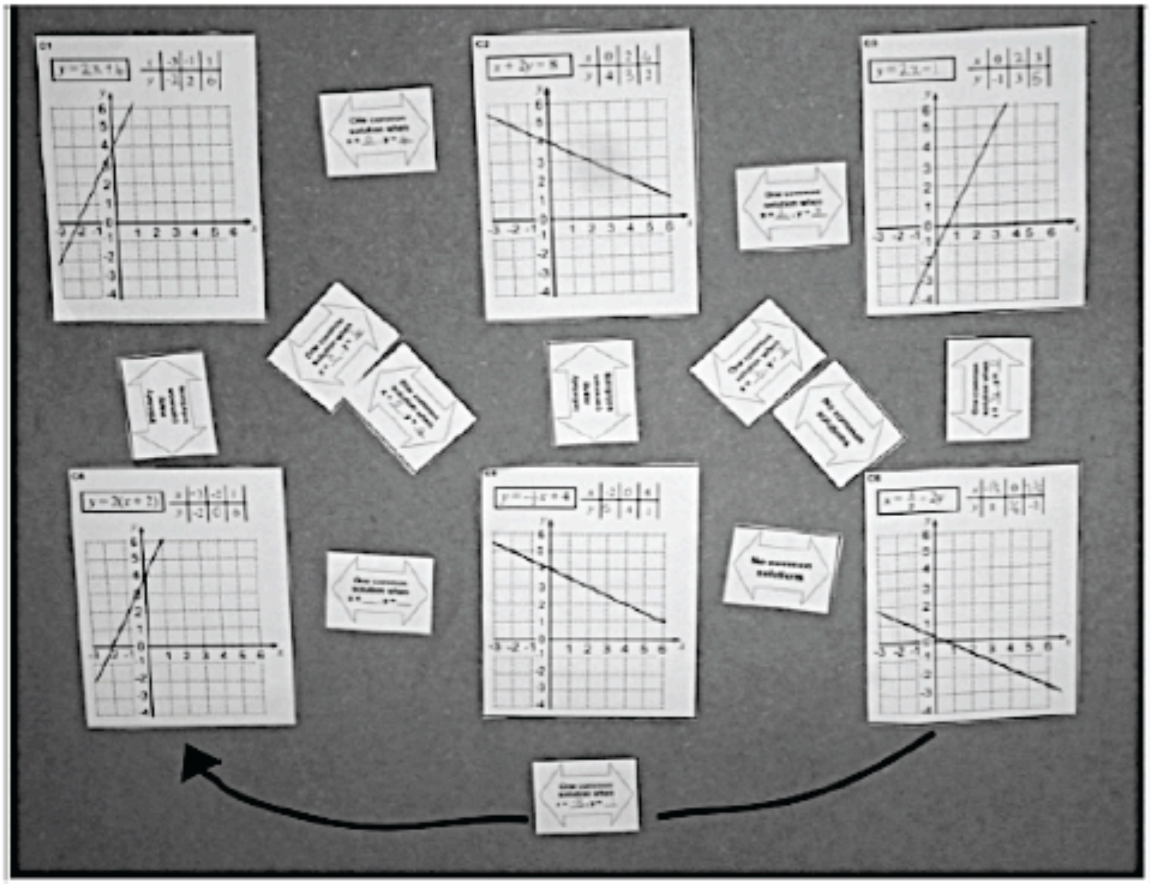
How might you use the Graph Transparency on your desk to help you to determine how many solutions the two cards have in common?

If students are struggling to identify how to use the transparency, ask them if tracing one of the graphs onto the transparency might be helpful. Some students may prefer to not use the transparency.

Notice how students are working and their method for completing the task. Are any students relying purely on the algebraic representation of the equation? Once students have recognized that there is one common solution, are they checking the solution algebraically as well as using the graphs?

As students work on the comparisons, support them as before. Again you may want to use some of the questions in the *Common issues*. Walk around and ask students to explain their decisions.

The finished poster produced may look like this:



Whole-class discussion (15 minutes)

Once groups have completed their posters, display them at the front of the room. Based on what you have learned about your students' strategies and the review of their posters, select one or two groups to explain how they went about addressing the task (if possible select groups who have taken very different approaches to the task). As groups explain their strategies, ask if anyone has a question for the group or if anyone used a similar strategy.

When a few groups have had a chance to share their approach, consolidate what has been learned. Using mini-whiteboards to encourage all students to participate, ask the following questions in turn:

1. *Show me two equations that have one common solution.*
   [E.g. $y = 2x + 4$ and $y = -\frac{1}{2}x + 4$].
   What are the solution values for x and y? [$x = 0$ and $y = 4$.]
   What happens to the graphs at this point? [They intersect each other.]
   On your mini-whiteboards make up two more equations that have one common solution. Don't use equations that appear on the cards. Sketch their graphs. Now show me!

2. *Show me two equations that have no common solutions.*
   [E.g. $y = 2x + 4$ and $y = 2x - 1$.]

How do you know they have no common solution?
[They are parallel lines so will never intersect.]
What do you notice about these two equations?
[They have the same coefficient of x/same slope.]
On your mini-whiteboards make up two more equations that have no common solutions. Don't use equations that appear on the cards. Sketch their graphs. Now show me!

3. *Show me two equations with infinitely many common solutions.*
   [E.g. $y = 2x + 4$ and $y = 2(x + 2)$.]
   What do you notice about the two graphs for these equations? [They are the same line.]
   Why is this? [$2(x + 2)$ is $2x + 4$ in factorized form.]

The focus of this discussion is to explore the link between the graphical representations of the equations and their common solutions, even though students may have used both the algebraic representation and the table of values during the classification process. Help students to recognize that solutions to a system of two linear equations in two variables correspond to the points of intersection of their graphs, as well as what it means graphically when there are no or infinitely many common solutions.

Follow-up lesson: *Working with Linear Equations (revisited)* (15 minutes)

Give back the responses to the original assessment task to students and a copy of the task *Working with Linear Equations (revisited.)*

Ask students to look again at their solutions to the original task together with your comments. If you have not added questions to individual pieces of work then write your list of questions on the board. Students should select from this list only those questions they think are appropriate to their own work.

Look at your solutions to the original task Working with Linear Equations and read through the questions I have written.

Use what you have learned to answer these questions.

Using what you have learned, have a go at the second sheet: Working with Linear Equations (revisited).

Some teachers give this as a homework task.

Appendix E

Analyzing Student Data

FAL Title: ______________________________ **Teacher Name:** ______________________________

Date of Pre-Lesson Assessment: ______________ **Date of Post-Lesson Assessment:** ______________

Analyzing Pre-Lesson Assessment Data				
Pre-Lesson Assessment Data	Demonstrates understanding **(3)**	Demonstrates some understanding (2)	Demonstrates little to no understanding **(1)**	No responses provided **(0)**
Number of Students				
What does the work reveal about the students' current level of understanding? What are the common issues? Summarize the difficulties by writing a series of questions.				

Analyzing Post-Lesson Assessment Data				
Post-Lesson Assessment Data	Demonstrates understanding **(3)**	Demonstrates some understanding (2)	Demonstrates little to no understanding **(1)**	No responses provided **(0)**
Number of Students				
What does the post-lesson work reveal about the students' current level of understanding? How would you summarize the growth of the students on this FAL? ***How will you use this information to guide future instruction?***				

Appendix F

SREB | Southern Regional Education Board

Powerful Mathematics Practices Rubric

Teacher ______________________ **School** ______________________ **Course** ______________________

Indicator	4	3	2	1	Zero or Not Observed
Ensuring a Balanced Approach to Mathematics To what extent is a balanced approach to mathematics (factual knowledge, procedural knowledge, conceptual knowledge) evident?	The teacher provides instruction, assignments and assessment items that present abstract or real-world non-routine scenarios promoting a balance of factual, procedural and conceptual knowledge.	The teacher provides instruction, assignments and assessment items that present abstract or real-world scenarios involving factual, procedural and conceptual knowledge, but the attention to each knowledge dimension is unbalanced.	The teacher provides instruction, assignments and assessment items that center around multi-step procedures and factual knowledge.	The teacher provides instruction, assignments and assessment items that center around simple procedures and/or factual information.	
	The teacher and the students articulate the *mathematical* goals of the lesson within the unit progression, linking the lesson with learning from previous instruction, and revisit the goals throughout the lesson.	The teacher articulates the *mathematical* goals of the lesson within the unit progression, linking the lesson with learning from previous instruction.	The teacher posts and/or articulates and the students record or otherwise acknowledge the *mathematical* goals of the lesson.	The teacher posts and/or articulates the *mathematical* goals of the lesson.	
	Students analyze an assignment, independently choose appropriate tools needed to complete the assignment, and justify why the selected tools are appropriate.	Students examine an assignment and independently choose, based on prior knowledge, appropriate tools needed to complete the assignment.	Students examine an assignment and choose appropriate tools to complete the assignment. Tools are provided by the teacher specifically for the assignment.	Students use tools chosen by the teacher to complete assignments.	
	Students examine and/or use multiple procedures or strategies to solve a given problem, critique the different strategies, and apply the most efficient strategy to their work.	Students examine and/or use multiple procedures or strategies to solve a given problem and critique the different strategies.	Students examine and/or use multiple procedures or strategies during the lesson to solve a given problem.	Students use one particular procedure or strategy during the lesson to solve a problem.	

Indicator	4	3	2	1	Zero or Not Observed
Engaging Students in Assignments that Matter To what extent do assignments advance mathematical reasoning with grade-level or above content?	The teacher provides complex assignments that require students to engage in problem solving and reasoning to complete. The students take the lead in completing the assignment and the teacher provides appropriate support.	The teacher provides complex assignments that require students to engage in problem solving and reasoning to complete. The teacher takes the lead in helping students complete the assignment.	The teacher provides multi-step assignments that contain scaffolding pieces for students.	The teacher provides assignments that are straight-forward and require little problem solving and reasoning for students to complete.	
	The teacher frames the assignment by articulating the *mathematical* purpose and success criteria and provides feedback to students throughout the assignment tied to its purpose. Feedback moves students' learning forward without telling them step by step how to complete the assignment.	The teacher frames the assignment by articulating the *mathematical* purpose and provides feedback to students throughout the assignment tied to its purpose.	The teacher articulates the *mathematical* purpose as a way to launch/frame the assignment and provides feedback tied to the purpose following the completion of an assignment.	The teacher articulates the *mathematical* purpose as a way to launch/frame the assignment.	
	Students engage in productive peer discussions without being prompted by the teacher to build shared reasoning and understanding of mathematical concepts.	Students engage in peer discussions when prompted by the teacher, sharing and considering more than one approach to an assignment.	Student discussions focus on comparing procedures and solutions.	Student discussions are limited.	

Indicator	4	3	2	1	Zero or Not Observed
Utilizing Questioning and Feedback for Deeper Understanding To what extent is questioning and feedback used to deepen student understanding?	The teacher asks targeted questions that require students to analyze, synthesize, and predict in order to advance their sense-making for a deeper understanding of mathematical concepts.	The teacher asks targeted questions that elicit student reasoning about a strategy and its relationship to the concept.	The teacher asks closed questions and follows up with "how" questions that focus on procedures and algorithms.	The teacher asks closed questions that require one-word or short answers from the students.	
	The teacher asks questions in ways that require *all* students to formulate a response and intentionally selects students to answer questions based on an instructional strategy (e.g., students with different approaches to a problem are chosen to share their ideas).	The teacher asks questions in ways that require *all* students to formulate a response and utilizes strategies that give multiple students a chance to share ideas (e.g., mini-whiteboards).	The teacher calls on students randomly to answer questions.	The teacher directs questions to a limited number of students.	
	When higher-order questions are asked or formative feedback is given, students are *always* provided appropriate time to process and engage in productive struggle.	When higher-order questions are asked or formative feedback is given, students are *frequently* provided appropriate time to process and engage in productive struggle.	When higher-order questions are asked or formative feedback is given, students are *occasionally* provided appropriate time to process and engage in productive struggle.	When higher-order questions are asked or formativefeedback is given, students are never provided appropriate time to process and engage in productive struggle.	
	Teacher feedback identifies student misunderstandings and how they are related to the underlying math concept. The feedback emphasizes a change in conceptual understanding among student(s).	Teacher feedback identifies student misunderstandings and emphasizes a change in procedural knowledge or understanding among student(s).	Teacher feedback identifies student mistakes.	Teacher feedback is non-specific and general.	
	Unprompted, students ask questions of one another about their reasoning (why-oriented questions).	Students ask each other questions to gain insight to each other's reasoning when prompted by the teacher.	Students ask each other questions about how to solve multi-step procedures.	Students ask each other questions to compare answers.	

Indicator	4	3	2	1	Zero or Not Observed
Using Formative Assessment Data To what extent does the teacher use formative assessment data to adapt teaching and learning?	The teacher uses formative assessment strategies throughout a lesson, acknowledges misconceptions exist, and makes adjustments to instruction in the moment. Adjustments are personalized to individual students.	The teacher uses formative assessment strategies throughout the lesson, acknowledges misconceptions exist, and makes adjustments to instruction in the moment. Adjustments are generalized and directed to the whole class.	The teacher uses formative assessment strategies throughout the lesson, acknowledges misconceptions exist but makes few or no adjustments to instruction in the moment.	The teacher uses few formative assessment strategies, if any, during the lesson with no adjustment to instruction.	
	The teacher purposefully poses problems that allow students to acknowledge the existence of *misconceptions*. The students have time to explore the *misconception* and clarify their *misunderstandings*.	The teacher purposefully acknowledges *misconceptions*, allows time for students to reflect on the *misconceptions*, and then clarifies the *concept*.	The teacher purposefully acknowledges *misconceptions* and immediately clarifies the *concept*.	The teacher acknowledges the incorrect *solution* and immediately provides the correct *procedure* and/or *solution*.	
	To summarize the lesson, the students and the teacher reflect on the conceptual and procedural knowledge and how they are connected.	To summarize the lesson, the teacher reflects on the conceptual and procedural knowledge and how they are connected.	To summarize the lesson, the teacher restates the concept for the day without any connection to the procedures.	To summarize the lesson, the teacher restates the procedure for the day without any connection to the concept.	
Fostering a Classroom Environment that Supports Student Ownership of Learning To what extent does the classroom environment support student ownership of learning?	Student collaboration encompasses the sharing of ideas, justifying approaches, critiquing others' reasoning, and providing others' meaningful feedback.	Student collaboration centers around the sharing of ideas, justifying approaches and critiquing others' reasoning.	Student collaboration centers around the sharing of procedures and solutions.	Student collaboration centers around comparing solutions.	
	Students are willing to be wrong in front of their peers and reflect and act upon each other's feedback.	Students share ideas and approaches and are willing to be wrong in front of their peers.	Students share only when they are confident their answers and/or solutions are correct.	Students share answers and/or solutions only when called upon by the teacher.	
	Students engage in productive struggle and persevere in completing challenging assignments that require reasoning and problem solving.	Students exhibit productive struggle and persevere in completing challenging problems when motivated by the teacher.	Students rely on the teacher and other students to tell them how to move forward step by step.	Students seek no support from the teacher or their peers and shut down when they get stuck.	

For lessons that involve a re-engagement assignment, the following section of the rubric should also be used.

Indicator	4	3	2	1	Zero or Not Observed
Adapting Teaching and Learning to Re-Engage Students To what extent does the teacher re-engage students in learning to deepen student understanding and to address misconceptions after a Formative Assessment Lesson (FAL)?	The re-engagement lesson is clearly designed to target specific misconceptions and the purpose of the re-engagement lesson is presented by the teacher at the beginning of the lesson and referenced throughout the assignment.	The re-engagement lesson is clearly designed to target specific misconceptions and the purpose of the re-engagement lesson is presented by the teacher at the beginning of the assignment.	The re-engagement lesson is loosely aligned to student misconceptions and the purpose of the lesson is presented by the teacher at the beginning of the lesson.	There is no effort to inform students of the purpose of the re-engagement lesson at any time throughout the lesson.	
	Students are strategically grouped by misconception and the re-engagement lesson targets these specific misconceptions. There is an extension activity for students who have already demonstrated understanding.	Students are strategically grouped by misconception and most students complete the same re-engagement assignment. There is an extension activity for students who have already demonstrated understanding.	The re-engagement lesson addresses student misconceptions but is the same for all students.	The teacher reviews the post-lesson assessment from the FAL and the students are correcting the items they missed.	
	At the conclusion of the re-engagement lesson, students have the opportunity to demonstrate an increase in conceptual and procedural understanding and reflect on struggles and growth.	At the conclusion of the re-engagement lesson, students have the opportunity to demonstrate an increase in conceptual and procedural understanding.	At the conclusion of the re-engagement lesson, students have the opportunity to demonstrate an increase in procedural understanding.	There is no effort to evaluate student understanding at the end of the re-engagement lesson.	

Appendix G

Interview Protocol

1. Tell me what a typical day's lesson in your math class looks like.
2. How often do you use technology to present a math lesson?
3. How often do your student use technology to participate in a math lesson?
4. What are some advantages/disadvantages for you using technology in math lesson presentations?
5. What are some advantages/disadvantages for your students using technology to participate in a math lesson?
6. What, if anything, have you observed in student learning from using technology?
7. How have you been trained to use the technologies that are present in your lessons?
8. How do you think your students feel about using technology in your classroom?
9. As more technologies are developed, how do you learn about new technologies to use in math?
10. Are there any thoughts you want to share about your enactments of the formative assessment lessons using technology and without using technology?

Appendix H

Student Technology Survey

Rate your agreement with the components of the questions as follows:
5 - Strongly Agree
4 - Agree
3 - Neutral
2 - Disagree
1 - Strongly Disagree

1. **I returned a permission form signed by me and my parent(s) giving consent to participate in this survey.**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

2. **I was present and participated in the lesson activity on A-day Friday, 4/13/18 or B-day Monday, 4/16/18.**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

3. **I have experienced the following technologies being used in my math class. Check all that apply.**
   Check all that apply.
   - [ ] Smart Interactive Whiteboard
   - [ ] TI-Nspire Student Software
   - [ ] MacBook Air Laptop Computer
   - [ ] Online Software (Examples: Desmos, Plickers, Kahoot)
   - [ ] Document Camera
   - [ ] Math XL online homework
   - [ ] Other: ______________________

4. **I like when my teacher uses technology to teach a math lesson.**
   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. **I like when I use technology to participate in a math lesson.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. **I learn better when my math teacher uses technology to teach a lesson.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. **I learn better when I use technology in a math lesson.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. **I prefer to have paper copies of work in math class.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. **I prefer to work hands-on with manipulatives in math class.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. **I prefer to submit my work online than to turn in my work on paper.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

11. **I am more successful in math class when my teacher uses technology.**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

12. I am more successful in math class when I use technology.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

13. Please provide any additional views that you have about technology use in your math class.

Appendix I

Dear Student:

I would like to invite you to help me with a project that I am doing at The University of Mississippi.

The purpose of this project is to help me learn more about technology use in mathematics classrooms. No one will see your answers except my instructor and me, and I won't use your name in any reports.

If you take part in my research, you will fill out a survey about using technology your learning in mathematics. It will take you about 10 minutes to finish.

You are free to quit this research at any time and I won't be upset with you. If you have any questions or concerns, please ask me now. Thank you for your help.

Sincerely,

LaVonda White

I agree to help with this research project. ❑ YES ❑ NO

Name: ____ Date: ______________

Appendix J

I. Oral Assent Script with Record of Child's (Aged 7-13) Response

I would like to ask you to help me with a project that I am doing at The University of Mississippi. If you agree, you would answer some questions about learning in your math class. It will take about 10 minutes.

What questions do you have about what you will do for me?

Will you do this?

Name: ____ Date: ___________ Response: ❑ YES ❑ NO

Appendix K

RANKIN COUNTY
SCHOOL DISTRICT
GREAT TO BEST

Post Office Box 1359 • Brandon, MS 39043 • p 601.825.5590 • f 601.825.2618 • www.rcsd.ms

March 2, 2018

Lavonda White
233 Turtle Lane
Brandon, MS 39047

RE: Research

Dear Ms. White,

My team has reviewed your information regarding your research study. I am pleased to grant you permission to conduct your research study using district data. I understand that all student identifiers will be coded or removed.

Best wishes in your educational endeavors.

Sincerely,

Sue Townsend, Ph.D.
Superintendent of Education
Rankin County School District

Appendix L

Consent for Your Child to Participate in Research

Study Title: *Student Views of Math Lessons Taught With or Without Technology*

Investigator
LaVonda White
Mathematics Curriculum Department
Rankin County School District
(601) 825-5590
lwhite@rcsd.ms

Advisor
Allan Bellman, Ph.D.
Associate Professor of Mathematics Education
Department of Teacher Education
The University of Mississippi
(662) 915-5309
abellman@olemiss.edu

The purpose of this study

We want to know whether a student's views about a lesson taught by a teacher using technology has different affects on their learning from a lesson taught by a teacher without using technology.

What your child will do for this study

1. Your child will participate in a normal class activity where the teacher either delivers the lesson using technology or the teacher delivers the lessons without using technology.
2. All students will complete a lesson pre-assessment, post-assessment, and collaborative activity as they normally do when the teacher gives this type of lesson.
3. All students with parental consent will complete a survey to answer questions about how they think the use of technology influences their learning. Students will answer statements (such as: *I learn best when I use technology to participate in a math lesson*) by choosing a number from 1 to 5 in a scale where 1=Strongly Disagree and 5=Strongly Agree.

Time required for this study

This study will take a normal class period of about 90 minutes for the lesson and post-assessment. The pre-assessment takes about 15 minutes of the class period prior to the lesson. The survey will take about 10 minutes for students to complete.

Possible risks from participation

There are no anticipated risks to your child from participating in the study.

Benefits from participation

Your child should not expect benefits or incentives from participating in this study. However, your child might experience satisfaction from contributing to scientific knowledge. Also, answering the survey questions might make your child more aware of his or her preference for learning in math class – sometimes this can help lead to improved learning outcomes.

Confidentiality

All information in the study will be collected from your child anonymously: it will not be possible for anyone, even the researchers, to associate your child with his or her responses.

Right to Withdraw

Your child does not have to participate in this study, and there is no penalty if he or she refuses. If your child starts the study and decides that they do not want to finish, they are to inform the teacher who will direct them to exit the survey. Whether or not your child participates or withdraws, it will not affect his or her current or future relationship with the school, and it will not cause your child to lose any benefits to which they were entitled.

IRB Approval

This study has been reviewed by The University of Mississippi's Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions or concerns regarding your rights or your child's rights as a research participant, please contact the IRB at (662) 915-7482 or irb@olemiss.edu.

Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, then decide if you want your child to be in the study or not.

Statement of Consent

I have read the above information. I have been given an unsigned copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent to allow my child to participate.

Furthermore, I also affirm that the researcher explained the study to me and told me about the study's risks as well as my right and my child's right to refuse to participate and to withdraw, and that I am the parent/legal guardian of the child listed below.

Signature ______________________________ Date ________

Printed name of Parent/Legal Guardian ______________________

Printed name of Child ______________________

Appendix M

INFORMATION SHEET

Title: The Impact of Using Technology in the Enactment of Formative Assessment Lessons in Eighth Grade Mathematics Classes

Investigator
LaVonda White
Mathematics Curriculum Department
Rankin County School District
601-825-5590
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Advisor
Allan Bellman, Ph.D.
Associate Professor of Mathematics Education
Department of Teacher Education
The University of Mississippi
(662) 915-5309
abellman@olemiss.edu

☐ *By checking this box I certify that I am 18 years of age or older.*

Description
The research in this project is being conducted to better understand if technology use in formative assessment lesson enactment impacts student performance in eighth grade math classes. The questions in this interview will focus on your experiences in teaching students mathematics using technology. Feel free to ask any questions you may have about the project. You will not be asked for your name or any other identifying information.

Cost and Payments
Besides the time devoted to participating in the interview, there is no other cost associated with this study. There are no payments for your participation in this study.

Risks and Benefits
There are no anticipated risks of participating in this study.

Confidentiality
Your identifying information will not be used for any part of this research project. Your school will also not be identified to prevent anyone from identifying you. The results of this interview may be shared with other doctoral students in this program and the class instructor. This interview will be recorded for clarity of your statements and the recording will be destroyed after the research project is completed.

Right to Withdraw
Your participation in this study is optional. You are not required to complete the interview, nor are you required to answer all the interview questions. Should you begin the study and then decide you no longer wish to participate, please inform LaVonda White verbally.

IRB Approval
This study has been reviewed by The University of Mississippi's Institutional Review Board (IRB). If you have any questions, concerns, or reports regarding your rights as a participant of research, please contact the IRB at (662) 915-7482 or irb@olemiss.edu.

Statement of Consent
I have read and understand the above information. By completing the survey/interview I consent to participate in the study.

My signature below means that I agree to all of the above terms.

____
Signature

____
Printed Name

____
Date

Appendix N

THE UNIVERSITY OF MISSISSIPPI

RELEASE

For valuable consideration, I do hereby authorize The University of Mississippi, its assignees, agents, employees, designees, and those acting pursuant to its authority (“UM”) to:

a. Record my participation and appearance on video tape, audio tape, film, photograph or any other medium (“Recordings”).
b. Use my name, likeness, voice and biographical material in connection with these recordings.
c. Exhibit, copy, reproduce, perform, display or distribute such Recordings (and to create derivative works from them) in whole or in part without restrictions or limitation in any format or medium for any purpose which The University of Mississippi, and those acting pursuant to its authority, deem appropriate.
d. I release UM from any and all claims and demands arising out of or in connection with the use of such Recordings including any claims for defamation, invasion of privacy, rights of publicity, or copyright.

Name: ____

Address:____

Phone No.:____

Signature:____

Parent/Guardian Signature (if under 18):_______________________

Appendix O

INTERVIEW TRANSCRIPTION:

Teacher A

Me: Tell me what a typical day's lesson in your math class looks like.

Teacher A: Umm we start with bell work through ah TI-Nspire Navigator software and the kids use on their computer. They log in, they are given 20 minutes or so to work anywhere from 5 to 7 questions. Umm they work in groups. Umm then we go over that bell work then we go into that day's lesson or can pick up where we left off the day before. Umm we don't usually end up with a lot of free time at the end of class, but if we do, we use an online program Math XL for homeworks so I let them go online and work on the practice problems that we would have covered in class that day. If we have time.

Me: Good. Um how often do you use technology to present a math lesson?

Teacher A: Everyday. 100%. Like I use my interactive whiteboard or their computer, Canvas, Nspire, all that.

Me: So that next question, how often do your students use technology to participate in a math lesson would be the same answer?

Teacher A: Uh, they use Nspire everyday, unless we're taking a quiz uh or a test. Umm, and then all, everything on their, their notes, everything is provided to them through Canvas so they can access anything, including videos of examples that I've worked. So they can watch it step by step, so I would say they may not open their computer everyday in class but their access to it is 100%. They, everything I give them, everything I show them they have access to outside of class as well.

Me: What are some advantages and disadvantages for you using technology in math lesson presentation?

Teacher A: Umm, I find that lessons run a little smoother. Umm with technology, I can kinda plan ahead umm. I feel like if we go back to traditional whiteboards you, you can only show so much stuff at one time where I can, you know if the kids miss something, the kids ask can you go back? Well yes, I can absolutely, I can flip back to something I just showed them and they can see it again, not to mention if I record during class, I can record it right there as I'm working it. The software is built into my Smartboard and I can upload to their Canvas. And so they have access to videos all year, all the time. And uh, so I think it makes everything run smoother plus they can see it in class and then if I've recorded it they can watch it again and they can remember…oh, that's what she said and that's what she did and all that, and so…I feel like it just makes it easier for them to access.

Me: Are there disadvantages?

Teacher A: Umm, I'm sure there are. Everything has a disadvantage. Umm, well I guess you know you always have to have that backup plan. You know you come in that day and the Smartboard doesn't work or, or the computer malfunctions. You know you always have to have a backup plan. Umm, so we do umm handouts that a lot of times will go along with our notes so worst case scenario if, if they came in and there was an issue with getting the interactive whiteboard, I would just go into a paper mode and we would use the boards and all that. So I guess you know relying on technology, that's, you know those, there's always that moment when, walks in and it doesn't work.

Me: Are there some advantages and disadvantages for your students using the technology that might be different from the things you just discussed with you using the technology?

Teacher A: Umm, I find that my students these days are digital natives, so they're so embedded in technology all the time whether it's their cell phone or their computer. You know, they know how to do stuff that I still don't know how to do and you know, I myself in dealing with technology. I feel like it speaks their language almost, if you deal with technology because it just all makes sense to them. Umm, but at the same time I feel like they, with the computer and everything else, they feel they need to be entertained and so if I did have a lesson where we didn't open our computers or we just had to sit there, they would be bored out of their minds. Umm, but we've also tried this year to incorporate activities, movement so they are not just sitting there in one place, on the computer, or you know, all day long, so.

Me: Ok.

Teacher A: Kind of a mix and match.

Me: What, if anything, have you observed in student learning from using technology?

Teacher A: What have I observed? Umm, I think technology allows students to be more organized. Umm one of the things I noticed is, is you've always got that kid who reaches somewhere into their book bag and pulls out something that they hope is whatever they are supposed to find. Whereas our Canvas, I've got it organized where their notes, their videos, the lessons, homework, extra practice, everything is organized so if you've got a child who has a really hard time keeping up with stuff, everything is electronically organized so they can access everything at any point. And it helps too, I've noticed that a lot of my students who are absent, umm I have several students who will, they know to go to Canvas. They know that the lesson's gonna be updated if they're a B-day student, they know just to wait until the end of the day. If's it's an A-day student, they know to wait until the end of the B-day. They know it's gonna be on Canvas. So I have a lot of students who will come in saying oh I can take the quiz just like I would have if I had been here because I watched your videos, I read over the notes and you know they come with their handout filled out. So it helps them stay with the class, with the pace. Does that means [inaudible], I've noticed a lot of my learners, you know they, they do that. Of course you have the others too that go what's Canvas? You know, oh you put that up? Oh, you had a test? You know, you still have the…what are we doing today? But I, I find overall, you know they take more ownership of their learning when they have access to it if they miss class. And I like that they can email me too. Like a lot of them will email me, I know I'm going to be out. So I'll watch for Canvas or ooh I was out, is everything on Canvas? You know they just own their learning a little better.

Me: How have you been trained to use technologies that are present in your lessons?

Teacher A: Umm well, Smartboard wise I just dove in. Umm years ago we had one Smartboard on campus that was on a cart and it was shared. And when teachers started getting Smartboards that one got passed down to me and I just dove in. I just played with it until I figured it out and now I just feel very comfortable with it. Uh Nspire, the computer program, we had training that we went to and we trained and again we played with it and the more you use it the more you learn about it. Umm yeah, so we had formal training for the Nspire and then the Smartboard I'm sure there was training at some point but I, I didn't have access to that. I just dove in and taught myself.

Me: Ok. How do you think your students feel about using technology in your classroom?

Teacher A: Umm, I think they like it. Umm, one of the things that I did new this year umm that I never done umm, recently we did a quiz using Canvas so it was a tech, full technology umm quiz and several students said they liked it better. And I don't know if it was the immediate feedback of the grading or if it was just the formatting. Some kids didn't like it. Some said, you know, I hope we don't do that again. So it's, you know give or take, you know just like we have to reach each learning style, technology kind of does that too. For some kids technology makes things easier to understand and others still need more traditional paper stuff.

Me: Ok. Are more…as more technologies are being developed how do you learn about new technologies in math?

Teacher A: Umm, I'm a, I'm on a couple of blogs and I'm on some message boards and umm but also mainly going to trainings. You know like the first time I ever saw a document camera I was at MCTM and the presenter used one. And I was like whoa, what could I do if I had one of those. Umm the swivel, um I did a study for Harvard. Umm they had me videotape my class and they sent me a tablet and a swivel and all that and so I just read the instruction manual and figured out how to use it. And then said what could I do with one of these. You know, so, I guess it's just being exposed in other classes and by other people and seeing how they're using it and then saying how could I adapt it to me, so, yeah.

Me: Ok. Are there any thoughts you want to share about your enactments of the formative assessment lessons using technology versus not using technology?

Teacher A: Umm, well this was the first time I did one of each kind. Umm, I will say that I found that the day I used technology the class, the lesson seemed to run smoother and we got further on that day than I did the previous day. The day, the other day, it took two days.

Umm and I also liked the technology day where at the end when we were sharing our matches that we all made, uh it was easier for the kids to go the board and show the whole class rather than having their individual posters. It was just easier for everybody to see what other connections other groups made. So I felt like it was a better group share with technology versus without technology. Umm I felt like looking at the pre and post, the results were about the same. I did not see where one day the kids seemed to have an advantage over the other, that they all seemed to make a lot of the same connections and a lot…we had the conversations were very similar. The lesson just seemed to go smoother and a little faster with technology as opposed to without.

Me: Ok. Alright. Thank you. That's all I have.

Teacher B

Me: Tell me what a typical day's lesson in your math class looks like.

Teacher B: Umm we start everyday with a uh TI-Nspire bell work of some sort, which usually involves a variety of standards. Uh we try to spiral review back into old material as well as umm some current material, so as kind of a brain starter. Umm after that there's usually a little bit of uh a transition and after we review the bell work together umm I do let students work together on their bell work. Umm I like it when they talk to each other and they have good math discourse. Umm then we move to usually into a lesson. Umm it depends on the day. Most days um, there'll be like notes and some independent work, and some more notes and some independent work. Umm but I do try to involve some umm activities and tasks as well. So some days might have more like a short 10-minute notes and then we move into an activity.

Me: Alright, how often do you use technology to present a math lesson?

Teacher B: Everyday. Everyday. Ha ha.

Me: How often do your students use the technology to participate in a math lesson?

Teacher B: Umm, in the beginning of class, always with TI-Nspire. Umm but after that it's not as often. Like after we do bell work.

Me: What are some advantages or disadvantages for you using technology in your math lesson presentation?

Teacher B: Umm for me it's an easy source. I don't have to rewrite the problems every single class. Umm for me it's also helpful because then I can also see what questions they are about to do. Umm and I like to provide a handout with my slides so that they don't have to spend the, you know, I know it's 30 seconds to write down some of these problems, but then umm they see what is on the board and they make the connection quicker, so.

Me: Are there disadvantages?

Teacher B: Oh yeah, umm I think that some disadvantages to technology sometimes it feels a little bit impersonal. Umm, I think a really big advantage though is also being able to upload all those notes online and using Canvas. I think that if we were to go backwards I think it would be very difficult, but umm disadvantages I think that there is some impersonalness to it. Umm, I think that parents don't always see it as an advantage and a positivity because of that impersonal value.

Me: Are there some advantages and disadvantages for your students using the technology in your math lessons?

Teacher B: Umm, in…for students the advantages are, well that's how their state test is gonna look. It's gonna be on the computer. So I think it's advantage to use the technology as much as we can in class so that they can prepare themselves for more what it's going to look like and how to use their computer well. Umm some disadvantages in math class, because they have to take the state test on a computer, I think that sometimes some of those great connections are lost because a, a lot of math you need to really be able to visualize and see and conceptualize and before we get to a computer, I would like to see that done by hand. So that I can better assess what to do to scaffold them to the next moment.

Me: What, if anything, have you observed in student learning from using technology?

Teacher A: Umm, well if you go back to the different types of learners, you got auditory learners and oral learners and umm visual learners umm I think that it definitely reaches a lot of people because its very haptic. Umm their putting their hands on something. Umm I have seen the students who I don't necessarily think would have succeeded if they hadn't had the technology. So, umm, I think that for those, some of those lower students it can be a really big advantage and okay I don't have to memorize exactly what this lesson said. I can always go and look back at it again when I go home. Umm, so you said disadvantages too, no just, yeah. I think that like seeing, seeing them interact with it too also helps me because technology is ever changing. Like I can be the master teacher person of Canvas, but they may still know how to do ten hundred times more things on it than I do. Umm so it's also fun to like see them explore and to see like their most like their, their, they want to learn how to use the technology and that's a big part.

Me: How have you been trained to use the technologies that are present in your classroom?

Teacher B: Umm, actually I started using Smart technology when I was in high school. Umm the actual technology, so my senior year I did a uh teacher mentor program in which I was a mentee and uh one of my old teachers actually was my mentor. And she, I was supposed to be just observing her class but she let me create lessons. And that was my first experience uh with Smart technology. Umm I had not really gotten to play with it that much though until I got my final job. So, even though that was my first experience with it, I hadn't seen it for a while. Umm there was not a whole lot of training at the very beginning. It was a lot of trial and error and pressing buttons and asking questions. Umm but I also am a forward thinker in that like if I can't find the answer I'm gonna ask somebody. Or you know research it. So, umm after though since I've been here now for a couple years we do have workshops with some of the technology. You know we did have training on TI, a little bit of TI-Nspire training which, uh at the beginning of the year. Or umm we can do a small short umm module about using the technology on the computer, so.

Me: How do you think your students feel about using technology in your classroom?

Teacher B: I think that since we don't use it after bell work, their faces light up when I say close your computer but leave it on your desk. Their face is like, they, they are so excited because they don't know what we're gonna do next for me. And I almost actually like that even though we don't use it as often. That moment when I get to say ok close it but keep it. They are like ooh we get to do something else, something different. Umm, so I think that they are a lot more excited about the use of technology. I do know some kids still prefer hand paper. Umm but I do know that they like, they get excited about it.

Me: As more technologies are developed, how do you learn about the new technologies that come out in math?

Teacher B: Umm, goodness. In college it was a little bit easier because my math classes would be focused on using, every once in a while, using Desmos and umm, we didn't have access to Smart but we had access to a bunch of other technologies. Umm I would probably as things come up and as administrators bring me new technology that's probably when I would start asking those questions. So if there wasn't a workshop for necessary training, then I would maybe ask for that to happen next. Umm but otherwise, I don't necessarily seek out as much. Umm I think that it's, it's about what is brought, been brought to me and about what I can do to manipulate what has been brought to me to put in my classroom.

Me: Alright, one final question. Are there any thoughts you want to share about your enactments of the formative assessment lessons using the technology versus not using the technology?

Teacher B: It was, it was the, the lesson itself went smoother, faster and I think that the kids understood a little bit more when I had technology. Umm when I didn't use technology, umm I think that there were some hiccups that could have been avoided using the instructions, seeing it in front of them. Umm that being said, the, the discourse between it was all the same. I think that there was good talking between the students between uh uh myself and them and umm it was also nice though on the technology day, we were able to manipulate all of these different pieces on the board and I thought that was really good because a group could go up and manipulate and then the others could uh see exactly what they were doing. So before a walk around umm they would be able to see kind of how their moving and thinking is working.

Me: Alright that's all I have. Thank you so much.

Teacher B: You're welcome.

Teacher C

Me: Tell me what a typical day's lesson in your math class looks like.

Teacher C: Umm…well, it's too typical, I think, and I probably do the same thing too much. But, most days they come in here, they get on umm TI-Nspire, umm we go through bell work, I give 'em between, probably, probably too long, maybe fifteen minutes to work through it and umm, try to walk around and make sure that the kids are giving their best effort because we don't grade it. I don't use it as a grading tool. Umm we collect the bell work. Umm, Umm we go over it. I let the kids, I let the kids see the results, always have the umm right answer green. Umm so we check through that, we go through any questions they have on bell work. We work any that we didn't do well. I usually just decide which ones to work. I let the kids guide me through, umm, pick some of the ones that got it right to guide me through. If we have multiple choice questions, umm, we try to figure out why we, why they chose the wrong ones usually that it'll kinda lead us actually to the right answer cause some of the wrong answers may be part of the way that you have to get or the calculations that you have to have. Umm after we do that we'll go in the notes. We've done a lot of hand-written notes and handouts and guided notes this year and most of the time it's not a go through notes and let 'em sit and do a bunch of problems afterwards. We just go through notes, we'll have some, some examples that I go through, then we'll have some guided examples and then I let 'em do independent, umm and then class is usually over by then.

Me: How often do you use technology to present a math lesson?

Teacher C: Most days just TI-Nspire. Umm, I don't use it a lot with the quick polls and stuff like I probably should, mostly because I don't have them premade. And I don't think, I, I don't let them have their computers out the whole time, probably cause of desk space, I guess that's part of it, cause there's not a lot of…if they have their notebook out. Umm, we've tried Canvas quiz, that went ok. The kids, some of the kids had some anxiety about it. Umm, we tried I think one Nspire quiz and that didn't really turn out how, how we wanted it to either so, so we didn't really delve into that much. Really just bell work. That's about as much as we use it for.

Me: Okay. So my next question was gonna be how often do your students use the technology to participate in a math lesson, but I guess their participation and when you are using it happens at the same time?
Teacher C: Yeah, um hum.

Me: What are some advantages or disadvantages for using technology in a math lesson presentation?

Teacher C: I mean, I like the, I like the bell work online or on Nspire cause it shows the results, umm, but at the same time, I don't, I guess the standard hadn't been set I have, I have a problem with kids like, if its on the computer, then their just gonna rely on the calculator and computer, they don't even think about getting paper out. But if you gave it to them on paper, their gonna try to write stuff down so there's an advantage of it makes it quicker I guess. Umm we can monitor their screens, I hadn't had hardly any problems this year with kids umm getting on different stuff for bell work at least, I mean they, they knock out the questions. Some get done and they check Powerschool or Canvas. I hadn't had a lot of umm technical discipline I guess with the computers in that aspect. Umm, I just think it leads a lot of kids not to show work or write anything down, they just figure it out I guess cause it's on the screen. I don't know cause, I think that's how they do Math XL too. They don't, to them it's just get on the computer they don't need paper here. Umm they don't use, they don't think of paper as a tool, they think it's a necessity, its just a formality that we do. They just get it out, but not as a tool to solve something. Umm a lot, and sometimes I give em like if we have a transformation in bell work or I try to give them a slip of paper or like a Pythagorean Theorem question where it gives the coordinates where you know I'll try to give them graph paper little grid, try to prompt them say hey when you get to number 5 that's what that is for. But then they still don't use it.

Me: So what if anything, I think you kinda touched on this already have you observed in student learning from using the technology?

Teacher C: I don't, I guess we just use it for bell work. I feel like, I feel like sometimes we just use it cause it's part of our routine, I don't know, we haven't done bell work without it this year so it's hard to, it's hard to measure like how it helped in reviewing things, we try to do a lot of reviewing bell work. Umm I don't know, I don't know if I have an exact answer to that question because we hadn't utilized bell work on paper and that's really the main way that we use it, so I don't know if I have a measure, umm.

Me: And how have you been trained to use technologies that are present in your lesson?

Teacher C: Oh for Nspire?

Me: Yeah

Teacher C: Oh, um…

Me: Any of the…

Teacher C: I know a couple of professional developments, hold on a second Hunter, Umm, I've been trained well. I went through uh Nspire training in professional developments at [X] County School District with [Curriculum Specialist A] and [Curriculum Specialist B], umm, and I guess [Curriculum Specialist C] was a part of one of those. Umm, they've also come to the school when I was in 6th grade math, umm, and they've come when I was in 8th grade during the summer umm and showed me how to set up uh my classes through an Excel spreadsheets and make that more efficient. Umm they've showed me how to utilize the data that we're given. Umm just any, any question that I had, umm they would come during our planning blocks in the school year, during the summer I had a great training at county office that took us step by step. Umm I guess the best, the best training was that we actually participated in, when we participated in lessons, in the activities for Nspire that where we could see it active. We weren't just given instructions step by step how to do things, we were told, umm, I mean we actually participated in a lesson to see how it worked and umm the facilitators of that training umm acted as teachers and, and showed us how we could use the feedback to, to teach or to have good quality teaching. Umm whatever that is, whatever teacher.

Me: Umm hum, how do think your students feel about using technology in your classroom?

Teacher C: I think they enjoy it, they, they enjoy the bell work because they can see their results. Umm they, they love it when they're right. They love the affirmation that they did something right and umm some of them, even if they have the wrong answer they, they just want to see their name pop up there. Umm I hadn't had any issues with kids being ashamed umm this year I leave their names up. I mean I guess it's now days kids just these kids are so comfortable with each other, they been in the same grade all this time but I haven't any issues with kids making fun and anything serious but umm they like that routine and coming in here and hopping on Nspire and going to the questions. It does get them engaged pretty quickly. Umm, but still you have issue with some of them actually utilizing every tool they can use, working it out on graph paper, stuff like that, so I, I, I think they enjoy that aspect of it cause it breaks up the monotonous of just the handwriting and the notes we do all the time.

Me: Now as more technologies are developed, how do you learn about new technologies for math?

Teacher C: Umm, professional developments we went to at [X] County, umm, we're told about websites, resources online, umm our principals forward us emails that, that they receive from curriculum specialists and different people in the district. Umm, hearsay as way, I mean you talk to different teachers that umm here at [County] Middle umm, [Teacher D] and some other teachers in the 7th grade, they utilize some updates with the Smartboards. I'm not real sure exactly umm I've never had to play with that myself but actually the respondus, I think it's respondus type technology, it's kinda similar to Nspire that just is supported by Smart. Umm and we participate in professional developments here. [Technology Specialist A] and I can't remember the other lady's name, but they come and umm, give us umm trainings. I think we've done 4 and he usually gives us a little tidbit that he knows. I think QuizIzz and some different things that I wasn't familiar with is what he presented to us, so, through email and um. I mean [X] County School District they are always, communication is good, umm,

Me: Good, and there is one final question. Are there any thoughts you want to share about the enactments of the formative assessment lessons using technology versus not using technology?

Teacher C: The…using the technology in the second day of the lesson, the B-day was much more efficient. Umm because when we went through the very first example, umm I had the whiteboard display and that was ok. Umm, but I would, I kinda would have to tell them hey, alright here's the equation y = 3x +2, what is the value of y when x is this two times, and what is the output value when x is this, what's the input value and that was fine, I mean they worked on their boards, but it took a litte more time. Umm but on the second day when we did the same intro, we had the Nspire document and we sent all four questions and we just put the umm the equation on the Smartboard and it kind of…it didn't take any more time I guess to work them out but all their answers for each question were there, we didn't have to wait to erase. So I guess it made it a little more efficient in that aspect. And then you got to see everybody's answers. Umm, I guess you can do that on the whiteboard too, but umm, I mean, the kids can see each others' whiteboard. So they could look on somebody else's and some would erase their work. Umm I don't know if that's, I guess that's not too different when it comes to the Nspire, but I really enjoyed that. I umm haven't been able to pull up a grid umm quicker where they could look umm when I showed them how the points related, the solution related to the line y = 3x + 2. The end of the lesson was the best though, is when you, when we got the card match and we pulled up the umm, Karin Bowen made the um, the slide where it had all three, all excuse me, all six of the cards completed and you could drag the uh, the no solution, infinitely solution, or many solution, the arrows and there was several copies over each other and it just made it easier where you could manipulate and see all the connections at once instead of just gluing them on umm, a poster where the kids couldn't see it real well. And the Smartboard and a better…I guess I could have taped it to the Smartboard but, um, I really like that because you could have every single match and you just keep going even if, even if…I know one block, umm, we ran out of time to make our own poster, but we got a bunch of matching because we just kept manipulating it on the Smartboard. So, umm, you know I don't know if it's any better with the directions, being able to put the directions on a projector, umm I didn't print it out for 'em, I kinda just told them verbally. I know the first day it wasn't smooth as the second day, so maybe that's evidence that, um having it cause I did let some classes read through the directions on the board if they didn't know umm what to do they could refer to that but some kids they still don't, they'll read over it and they still not sure because it, it…I guess they are not used to the process of going through a type of lesson like that. Umm but I definitely, I definitely felt hindered the day I didn't have it. Cause I couldn't, I mean you…everyday you cut on the Smartboard and everyday we use Nspire, so it definitely made me feel more uncomfortable not having umm just the ability if I just wanted to pull a grid up or just pull…I could just Google a picture right quick and slap it on a slide and it was there and it's a lot harder to do that, to draw that on a whiteboard real fast. I don't have any grids, grids that are on whiteboards, so, umm, yeah.

Me: Ok. Alright, well that's all I have. Thank you so much.

Appendix P

School ____________________________ Observer ____

Date ______________________________ Teacher Observed _______________________________

Grade/Subject __________________________ Time in ___________ Time out ____________

Observation Look Fors and Evidence:

1) Use of Technology

2)

Comments/Questions/Suggestions:

Appendix Q

Transcript of Observations Debrief 10-31-2018

Participants: Teacher A, Teacher B, Teacher C, and Researcher

Researcher: Ok, so, part of our follow-up from our previous research was to go in and observe each one of our peers. And so, I have a couple of questions that I want to ask you all about the observation. Umm, were there any adjustments that you made to your lessons after you had observed your peers?

Teacher A: Umm…I did not make this adjustment only because it wasn't easy to get to but I liked how we had the bell work question about the cube. And you had the actual cube (directed at Teacher B) and I saw you do it as well (directed at Teacher C) and you actually [inaudible] like had a conversation. Like I had a conversation with my students about what do you remember about a cube? What do you know about a cube? But you actually, physically had your cube out and you know could touch it and let them touch it and all that, so that was something I was like that…

Teacher B: As soon as he pulled his out I w…

Teacher C: Like I…like it just popped in my head and I just knew where it was

Teacher A: Right…mine is not easy to get to but next time I'm gonna have mine ready.

Teacher B: See I observed him 2A, so coming back into my classroom, I literally went and g…went and dug it out, cause I was like, I need to do this.

Teacher A: Well it reminded me of …that's the first time I thought about it, but you know all the time we were talking about volume that's a perfect time to have that physical model out ready to show them this is what we're talking about, this right here…you know…so I thought that was really good.

Teacher C: So, with your bell work, [Teacher A's] bell work…so, I have always used the answers…like sometimes I try to click, I uncheck show answers that way they don't know what the right answer is and I never spend much time thinking about how to make that efficient and where I always run into a problem would be like if they typed it several different ways. Not only if they had a bunch of different answers and if it was a hard question then you have a ton of just random answers like an equation with fractions but if they typed it a certain way then you had more responses. So it was so ineffective to try to mull through. It's like you couldn't center in on…

Teacher A: You're talking about on Nspire?

Teacher C: Well on Nspire, and so when, I didn't…I knew you modeled it for 'em…like on the paper, but I like how you collected it, then you asked them to answer…what the answers were, then you went over it. And then you went back and reviewed the responses. Because you were st…you were checking umm, to see if they knew and you made, made sure they understood and that they got the right answer…but you were using…you're using the Nspire more as a motivation. It is a formal assessment for you, but to them it's strict motivation and it worked like…and I thought that was your high class…that is…

Teacher A: That is not my high class.

Teacher C: That is how they tricked me…cause I figured they would be, the way they interacted with bellwork.

Teacher B: So how did you do it, cause I didn't get to observe yours [opening lesson].

Teacher A: So, you know just like we all do I give out the Nspire.

Teacher B: Yep.

Teacher A: And then I, I kinda, I usally give 'em no more than 20 minutes unless it's extra questions or it's extra hard or something and I walk around the room while they're doing their thing, but [inaudible].

Teacher B: Yeah.

Teacher A: And I always warn them like you got like 60 seconds then I'm taking it whether you are done or not cause I do warn them you might not all get done

Teacher B: Yeah.

Teacher B: So once you take it though…

Teacher A: I…I collect it and then I have it held over there and then I turn to a notebook page that looks like a piece of notebook paper and I go over the bell work and so they are telling me what their answers are and I'm working the problems so they then know what it should look like on their piece of paper for binder check.

Teacher B: So you're modeling it?

Teacher A: I'm modeling it and letting them correct…cause I mean…you weren't here [Researcher] for the first several weeks, but like literally I can't tell you how many times I said if you've got them wrong on your paper what should you be doing? Fixing it. And so they've learned that when I start working, that's when they start comparing cause I'm gonna write up on the board what they should have written down on their paper. So that when binder check comes around they're not just writing down some random answer. If theirs is wrong that's the perfect opportunity to fix it and ask questions.

Teacher B: So do you just have like a notebook file that you…

Teacher A: It’s called bell work blank.

Teacher B: So it’s just a…

Teacher A: It’s a blank piece of paper, we title our page…

Teacher C: It’s lined.

Teacher A: It’s lined like a piece of notebook paper

Teacher B: So you’re modeling it every time?

Teacher A: Every time.

Teacher C: Right and they writing them

Teacher A: And then their working…their double checking theirs against mine and then fixing whatever might be wrong right then.

Teacher B: I can tell ya’ll, I …

Teacher A: Cause I know they’re not going to once they turn to that next task, that bell work is done, they’re never gonna think about it again. And then, once I go to the last one, I’m like okay let’s see how we did as a class.

Teacher B: Umm hum

Teacher A: And I go and I look at the r…I look at the data pages.

Teacher B: So does your bell work, could your bell work take up to forty-five minutes then.

Teacher A: It doesn’t usually take 45 minutes, it usually takes about 30. Cause by the time I model it and then when I go back to the Nspire, it’s like this (3 finger snaps)

Teacher B: Cause I do...

Teacher A: This is how we do.

Teacher B: I say bell work, if it’s a short day it’s always 10, but then if it’s a longer questions or harder questions then I give 12 or 15 minutes. But I’m wondering if I should give them more time then.

[Inaudible]

Teacher A: I pretty much stick to my 20 minutes as far as letting them work because in every class I know who my slower workers are…like…not as like poor productors, just slow. And…but I also monitor too like I walk around like my class is actually my 2A. So I'll walk to every group, if they're done early we go on. I don't just set the 20 minutes and sit there until the timer goes off. I'm walking around so if they are all finished early, shoot we go on. Like you know, it's…it's not like a timer thing…I just…guys, ya'll it's been 20 minutes, I can't wait any longer.

Teacher C: That was a…that was a quicker bell work.

Teacher A: Right, it had 6 questions but there were several multiple choice that moved faster. And if they work together, they work faster too. I've got group…I've got classes that…whose…the groups work better together than others. So it just kinda…

Teacher C: With like, one of the questions was multiple choice, so say the answers were…each answer was a sentence or whatever. She wrote D. So then you eliminate the question of do I have to write the whole answer down or do I have to…you know. I get those questions all the time, do I have to write the equation down, or do I just write the letter D or what do I write? Umm…

Teacher A: And I know, maybe because we've done binder checks a few now, I know what kinds of questions we will look for later and I'll waste less time with what they have to write down on a piece of paper on ones I know we are less likely to ask for later, anyway. You know we're gonna go for those equation questions where they show their thinking or we're going to go for those where they have to explain something and less for those just straight mathematical multiple choice.

Teacher B: I think I'd have to…I don't know if I'd have to…I don't know if I could start immediately doing it that way cause the way that I do bell work right now, is very different from both of ya'lls. Both of you model, you ended up modeling that and I don't. I'm walking around, I'm up getting…I…I do the first like 3 minutes, 4 or 5 minutes, half the time whatever saying you work on own, only talk to each other. Then I come in at the end.

Teacher A: I did notice that your going over it was a lot faster. And I wondered if you did model…maybe not even all of them, but just some of them. Or like if you took a second and looked at the most missed and just model the most missed ones, it would have went by faster.

Teacher B: See, I need to learn to use the TI-Nspire software better. Because I usually ask them how did you do you then I'll work through parts of it if I think that it's really tricky and it might be hard for them to explain, but my kids work for the collective clap. That's all…like that's what they really like, they right…like to get a collective clap. When everybody gets the answer right, everybody gets one big clap. But I could still do that.

Teacher A: Yeah, because they don't see the results until after you have modeled it anyway. Like you're talking about it, then, like I said, after I've modeled the whole thing, then I go back and ok let's see how we did, and again I harped on at the beginning of the year was…you know we're going to tank it sometimes, we just are especially if it's got several new skills on it but the idea is for us to grow each time. Like that day when [Teacher C] saw my 1A, they grew like 15% from one day to the next, or maybe even more than that. It was their highest to date. Like they knocked it out of the park, they were so proud of themselves.

Teacher B: Ok, I need a TI-Nspire lesson. I think that's what it comes down to.

Teacher C:

Teacher B: I'm not…I don't know where these things are, the percentages is on each question, like when I save it, the first thing that pops up, like I know minimal, I know how to send the document. I know how to write the document, I know how to send the document, how to collect the document, how to save the document, and how to open the document.

Teacher A: Yeah, you and I can work on that, cause it's not a hard thing to show you, yeah.

Teacher B: I'm just gonna write that down cause that's definitely something I want.

Teacher A: If you ever want to come back in here during another 2A, just…like I can text you and be like okay come in here in 3 minutes and you can see how it's done.

Teacher B: Yeah, that might be a good idea. Actually a good idea.

Teacher A: Ok.

Teacher B: Uhh, other stuff going straight from watching, then going back to my room…I'm trying to think…umm I reworded how I asked some of my questions based on the way that you did [Teacher A]. Umm you said your job was to figure out if this is true. Uh referring to does 15 squared plus 20 squared equal 25 squared. And I thought that that was a really good way to say it, because you weren't specific about, you know do this, then do this, then is it true, you said your job is to prove whether or not it's true. So I like that you gave the direction and not necessarily the question. Like they took responsibility for it, which I liked.

Teacher A: This Pythagorean Theorem unit has been really good.

Teacher B: Yes.

Teacher A: This is the first year converse has made so much sense to them so easily. I think we've done a really good job this year. When we made that adjustment in how we worded it, the if-then statement, like that just seemed to make so much sense to them. Yeah. And the love how we were able to tie it to like science like aren't ya'll using if-then statements in science. Yes, we doing hypotheses and I was like yes, you are, I knew this.

Teacher B: I'm trying to think if there's anything else.

Researcher: Cause there may be some strategies or some methods that you saw that might influence some of your future instruction that maybe you haven't gotten around to implementing yet. Was there anything that might stand out?

Teacher B: I liked [Teacher C]'s question about why is square root of 2 irrational. And you were looking for 3 things. And I didn't even think of the third thing, so irrational numbers are…cannot be written as a fraction, do not have a pattern, and do not terminate or do not repeat a pattern. Those are the 3 big things that I talked to my kids about and I talk to them about perfect square is and we go through that and I mention it, but I don't hit on it repeatedly because there are other ways to determine if it's rational or irrational. Like knowing something, but here the last thing that you were looking for is it's not a perfect square. Which again I think that's a great concept, it's just not something I personally focus on every time. So I know that that's something that I would like to do more. Like…and I keep saying, I say what are my perfect squares and they like 1, 4, 9, and then I'm like ok and the numbers in between. So I say what is between 1 and 4? Well 2 and 3. Well square root of 2 and square root of 3 irrational. What's between 4 and 9? Five, 6, 7, 8, square root of 5, square root of 6, square root of 7, square root of 8 irrational.

Teacher A: Well I think too you know, we ask them to memorize the small perfect squares and cubes because they should recognize them. But I think there are some that are still not making the connection because they didn't memorize them. They're gonna do the math when it comes time to like do a quiz, they're gonna just do the math in their head so they don't commit to memory, so then they are not making the connection to oh the ones I memorized are perfect so the ones in between would obviously be irrational. To them it's not obvious.

Teacher B: So maybe…maybe we need to do something where, like we start doing flash cards with them or we alternate doing flash cards with the, the one solution, no solution, infinite solutions and squares and cubes, because I think that there are benefits other than being quick to memorize those. Like understanding what a perfect square is, what a perfect cube is.

Teacher A: Even putting the approximates on a number line, if they know their perfect squares and they can recite them so quickly they at least have a much more reasonable chance at figuring out where an imperfect square would go, you know and approximate it.

Teacher B: And the one…one thing I do…I did notice they still can't say that, they can't say it's a cube root. Their like the squiggle thiggy ma giggy and I'm like a root. And I keep saying root, radical, square root, cube root, and it's just not setting in. But I think it's because we don't make them say it enough.

Teacher A: Well, I think it's going to be my next poster. I'm going to make like a theme. I've got it kinda in my head.

Teacher B: You have a new poster in mind.

Teacher A: Yes. And like…so they can use the correct vocabulary, so they know what we are talking about and we're not, you know…

Teacher B: Well that would be another one to put for this unit. So I agree with that.

Teacher A: Um hmm.

Teacher C: You know it's…it's so easy like on test be like look, if you take the square root or cube root of the number and you get a decimal in the calculator it's irrational.

Teacher A: But you got to be careful about saying that.

Teacher C: Yeah, you can't because though umm because you can get, you can take a fraction and get a rep…a repetition that's huge.

Teacher A: Right. We've talked about that where it might take 7 places and it would be…

Teacher C: Cause, cause if it's uh two-thirds, they recognize that it repeats but if it's anything divided by 7, repeating is like 5 or 6 numbers and they think it's irrational, they go "it doesn't repeat", cause they don't recognize the rounding.

Teacher A: Right.

Teacher B: See I keep telling mine, I say no matter what, 2nd PRB enter, because if it can be turned into a fraction, it is rational.

Teacher A: Right.

Teacher C: That's the definition of it.

Teacher B: Um hmm that's like the big one.

Teacher C: But then you know I catch…then I screwed up some of them saying if it's a fraction, well if it's the square root of 5 over 4, then it's not. So then you gotta say…

Teacher A: Well a fraction made up of integers.

Teacher B: So we…I mean so…

Teacher A: We had that, a lot of mine were like, well now [Teacher A] pi over 4, this is a fraction but it's got pi in it and we had a whole conversation about it being an integer.

Teacher C: But you got to be careful about saying integer too. Cause you got…you can say it's not proper, but you could say a fraction of rational numbers. Because if it's decimals they are technically not integers.

Teacher B: Yes, so this is like this one, 6.3 divided by 7.5, I said…

Teacher A: Well that's a complex fraction, is it not.

Teacher B: Yes, but we don't say this is a fraction. Again I tell my kids put it in your calculator and 2nd PRB because your calculator will do the hard work for you. Now I l know I can multiply both of these by ten and just move the decimal places.

Teacher A and Researcher: Right.

Teacher B: But they don't…they don't see that.

Teacher A: Well and your denominator can't be zero.

Researcher: It can't be zero, right.

Teacher A: And you can't say rational number, cause zero is rational but it can't be in the denominator.

Researcher: Umm hmm.

Teacher B: So it's really…

Researcher: I mean that definition really is it has to be an integer divided by an integer where the denominator is not zero.

Teacher B: Which is why, which is why the definition says A over B where B is not zero. Ok, so then…

Teacher C: At the same time you are not asking them to write a proof. Sometimes there is like you may have to modify even though it's not mathematically correct.

Teacher A: Cause my kids love to say all fractions are rational. Well, yes as long as you know there are exceptions, you just have to be careful.

Teacher C: We're not calling it necessarily a fraction.

[Inaudible chatter]

Teacher B: Well, and that's what one could ask me, they were like, negative pi over 6, he goes is that division or is it a fraction. And I said that's a great way to put it because that was my question, I said well and that's what I asked a kid once, I said pi over 6, is it a fraction? And they were like yeah it's a number divided by another number and I said ok but what can you tell me about pi. You know, and like we tied that conversation but the way that kid said it I thought was really important.

Teacher A: Well and I…and I've even tried to be very careful about saying, you know if it's got pi attached to it, it's irrational. You can't say that either because we've all seen that example where it's pi divided by pi.

Researcher: Yes.

Teacher A: So we have to be…

Teacher B: See I mention that…

Teacher A: Every time we say something, if it's this, but you got to think of those exceptions, so you have to be real careful.

Teacher C: So I say if it's got one pi, like if there is just one of them.

Teacher A: Right.

Teacher C: You can guarantee. And I just…if there's two of them then…

Teacher A: It depends.

Teacher C: Some I [inaudible] like good luck, hope you…you know like.

Teacher A: So when all else fails, put it in the calculator.

Teacher B: So one pi we're feeling pretty irrational after eating a whole pi.

[Inaudible chatter]

Teacher B: And then, I mean two pi's…I don't know, I'm trying to get something silly that we could say. I do that a lot.
Researcher: While you're thinking about that, umm let's reflect on the observation process because I think I had asked you all before had you ever observed one another you had told me that you had not, so umm what are some of the takeaways just from that process.

Teacher A: You've been in my room several times during 1A cause you're off [directed to Teacher C] so you have observed but we haven't done like a team. But I really like it, like I like seeing how you might say something different or you might question something different. It's one of those things where yeah I wish we did that but it's also a time thing. Like you know one day we are all off differently so we could do that, we could say once every unit let's take a day and each yeah…

Teacher B: Swap

Teacher A: And I really think that we would get a lot out of it if we just made ourselves do it.

Teacher C: And…I…for me, we all can talk and plan and talk and plan and come up with all these good things but there is nothing like an hour before the lesson when our teacher brains kick on and stuff starts popping in our heads to adjust.

[Someone]: Umm hmm

Teacher C: There is stuff you do, stuff you do and stuff that I do that may not pop into our head when we are all just worn out from teaching all day and trying to put all this great unit together and we're letting each other know.

Teacher A: Or may even do something that we didn't really think about doing, we just did it, but we didn't think about sharing, you know like, we might just do something the spur of the moment like the day ya'll were here I flashed rational number cards. I literally thought of that the morning of. I was like, you know what, we're gonna have a couple of minutes in between transitions let me just do that because that's something in our unit but not in this lesson and it was just something I…spur of the moment. And [Researcher] and I when we talked after, she said did you consider…cause at one point the kids were complaining because the cards were so small…she said well did you think about like maybe just putting them on the Smartboard so everybody could see and I said it was something I just thought of at the spur of the moment I didn't even…

Teacher C: I found a…I found a Quizlet of flashcards where you just press…it's already made…and when I…I started doing that because it was…I was like…you know what all them kids were complaining because they can't see them and I ain't about to write all these flash cards.

[Laughter]

Teacher A: But yeah…but things like that…and I even thought about my flashcard game I made with the one solution and all that. I even thought, why am I making big cards to hold to everybody when I could just put them on the Smartboard and everybody could see at the same time. I could just open up my clicker, so…

Teacher C: But there is stuff we do every single lesson that we don't think about, we just adjust and we just…it pops in our head and we just fake it 'til we make it and you know…seriously…

Teacher A: And if we decided to do this once a unit or even more often we could say, you know what this time let's hone in on let's watch each other's questioning or let's watch each other's time management or transitions or wait time. We could pick something…

Teacher B: I think that we could all…

Teacher A: To give each other feedback cause we're as transparent you know we can, we can…

Teacher B: That is something that goes for us, the benefit comes from the fact that we are open with each other, we trust each other, and we know that it's always coming from a good place.

Teacher A: I mean we know who's lazy, we know who's not.

[Laughter]

Teacher B: But would like…you're right if we, if we, we would have to plan the time because we don't want to lose so much of it that we don't get the things done that we need to get done. But I can tell ya'll like my 1A to my 7B it's…it feels like a completely different lesson sometimes.

Teacher A: Yeah.

Teacher B: Like sometimes I start and where I finish is completely different direction, you know I still hit all the main marks but I feel…I always feel like I do better day 2 or I do better the one after.

Teacher C: Yes. Cause my…my 2A gets the shaft. I feel like the rest of them I stick to my guns on but…

Teacher B: Yeah, oh yeah, that's how I feel about my 1A.

Teacher A: I think we should…I think we should maybe

Teacher B: Plan out…

Teacher A: And start with that next unit…

Teacher B: Yeah.

Teacher A: Especially with exponent laws coming up.

Teacher C: All we got to do is the A-day off block we just need to spend 30 minutes…[inaudible]

Teacher B: We could plan a day, we could literally pick the day, this is the lesson.

Teacher C: Yeah.

Teacher B: This is what we're going over.

Teacher A: And have an objective, I like it.

Teacher B: Yeah. It should be two things. We should pick the day, here's the objective, and here's the thing we're gonna focus on and observe and come back and talk about and we can literally talk about it the next day because that's our planning block.

Teacher A: Yep.

Teacher B: [Inaudible]

Researcher: Thank you. I appreciate it. Thank ya'll so much.

VITA

LaVonda White

EDUCATION

Master of Science (July 2005) in Mathematics, Mississippi College, Clinton, Mississippi.

Bachelor of Science (May 1996) in Mathematics, Alcorn State University, Lorman, Mississippi.

Bachelor of Science (May 1996) in Computer Science, Alcorn State University, Lorman, Mississippi.

ACADEMIC EMPLOYMENT

Curriculum Specialist, Department of Curriculum, Rankin County School District, July 2013 – present. Responsibilities include: monitoring and evaluating curriculum implementation for grades K-12 math, coaching mathematics teachers, and developing and facilitating professional development sessions.

Teacher, Department of Mathematics, Hinds Community College, August 2009 – present. Responsibilities include: facilitating student learning in Intermediate Algebra.

Teacher, Department of Mathematics, Brandon Middle School, August 1998 – May 2013. Responsibilities include: developing lesson plans for seventh and eighth grade math and Algebra 1, chairing mathematics department (2003 – 2013), and managing monthly teacher leader staff development.

ACADEMIC AWARDS

District Employee of the Month, Secondary Curriculum Department, Rankin County School District, September 2018

District Teacher of the Month, Secondary, Rankin County School District, April 2008

Presidential Award for Excellence in Mathematics and Science Teaching (PAEMST), Awardee for Secondary Mathematics, National Science Foundation, 2007