An Evaluation of Students' Perception of Thinking Maps®
in the Middle School Mathematics Classroom

Capstone Research Project

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Chapter 1: Introduction

The function of education is to teach one to think intensively and to think critically.

-Martin Luther King, Jr.

New curriculum and testing expectations have put pressure on educators like never before to prepare students to be critical thinkers. In order to support students in critical thinking, educators have used graphic organizers, concept maps and other organizational tools. Programs such as Thinking Maps®, The Critical Thinking Co.®, Mind Maps® and Learning-Focused® have been packaged and marketed to schools as "proven" techniques to support teacher effectiveness and student achievement. The purpose of this research was to examine student perception of one of these programs – Thinking Maps®.

Problem Background

In 2005, Georgia implemented new curriculum standards referred to as Georgia Performance Standards (GPS). Under GPS, math curriculum underwent drastic changes. The new performance standards required a "greater depth" than previous content standards and required students to "manipulate and apply the information" ("Curriculum Frequently Asked Questions," 2015). In 2012, Georgia joined 44 other states in adopting the Common Core State Standards (CCSS). The new CCSS required an even greater level of student understanding and expectations. The new standards were designed to "ensure that all Georgia students have an equal access and opportunity to master the skills and knowledge needed for success beyond high school" (Georgia Department of Education Assessment for Learning Series Overview PowerPoint, Slide 3). The new standards required students to reason mathematically, evaluate mathematical arguments and use the language of mathematics to communicate information and connect mathematics to other disciplines ("Mathematics," 2015). Not only are students required to know math computational skills, they are required to think about the mathematical skills and concepts, and explain how and why through the incorporation of the Standards for Mathematical Practice (Burns, 2013; Faulkner, 2013; Giouroukakis & Cohan, 2014).

In addition to the new state standards, Georgia has implemented a new test, Georgia Milestones Assessment System (GMAS) for the spring of 2015. This new assessment is designed to ensure that "students are provided with rigorous thinking experiences that lead to the mastery of learning standards" (Georgia Department of Education Assessment for Learning Series Overview PowerPoint, slide 3). In contrast to the former assessment, the CRCT, students will have selected response questions (formerly called multiple-choice questions), constructed response questions, and extended constructed response questions on the mathematics portion of the GMAS. The constructed response questions are designed to require "more elaborate answers and explanations of reasoning" (Georgia Department of Education Assessment for Learning Series Module 2 PowerPoint, slide 2).

New curriculum standards and testing policies require more from students than ever before. Content mastery is not simply knowledge of the content, but the ability to apply the information to new situations and justify reasoning. Students are required to use higher order critical thinking skills to synthesize what they have learned. Ennis (1993) defined critical thinking as "reasonable reflective thinking focused on deciding what to believe or do" (as cited by Rosen & Tager, 2014, p. 251). Critical thinking involves evaluating, analyzing, making inferences, making decisions, and solving problems (Rosen & Tager, 2014). Additionally, critical thinking includes analyzing part to whole relationships, synthesizing information and asking meaningful questions (Rosen & Tager, 2014).

Students are also required to have reading comprehension skills to understand the rigorous questions asked on the GMAS. Solving a mathematics word problem "requires the ability to read, decipher the problem, determine what is unknown, understand arithmetic operations, choose appropriate operations, use strategies, attend, hold information in working memory, understand vocabulary, adjust thinking, and access metacognitive and self-regulation skills" (Wilson, 2013, p. 36). For many students this is an overwhelming challenge.

Thinking tools have been developed to enable students to represent what they have learned and know by organizing and representing knowledge. (Hwang, Wu, & Kuo, 2012; Marulcu, Karakuyu, & Dogan, 2013; Rosen & Tager, 2014). One such tool is Thinking Maps®, developed by David Hyerle in the early 1990s. Thinking Maps® consists of eight graphic organizers based on fundamental patterns of thinking (Hyerle, 1994). These visual tools are intended to be used by learners at all age levels to connect, share and reflect on information (Hyerle, 1994).

Statement of the Problem

Thinking Maps® was introduced into the researcher's school in 2012. Implementation of Thinking Maps® began with whole faculty training to introduce all the maps to the faculty. A roll out plan was used to introduce the maps to the students in all content areas. Since that time, the faculty has received follow up training from a Thinking Maps® trainer focusing on implementing Thinking Maps® in specific content areas. Complete implementation of Thinking Maps® takes between three to five years.

The school purchased licenses for the Thinking Maps Learning Community (TMLC), an electronic platform for generating and organizing Thinking Maps®, for the 2014-2015 school year. Teachers began receiving training on the TMLC in the fall of 2014. Students were introduced to the TMLC in January 2015. Prior to the TMLC, students created Thinking Maps in the math classroom on an iPad using an annotation app called Goodnotes.

The researcher participated in multiple math Thinking Maps® training sessions and a five-day Trained Trainer session to be a Thinking Maps® trainer within the school district. In addition, the researcher attempted to incorporate Thinking Maps® into mathematics instructions in order to support critical thinking skills in the mathematics classroom. The researcher is interested in determining students' perception of Thinking Maps® and if Thinking Maps® is provided the support that students need to be successful in mathematics.

Purpose of the Study

Thinking Maps® has been an integral part of the mathematics instruction in the researcher's classroom for almost two years. In addition, students have used Thinking Maps® in all content areas for almost two years. This research evaluated if classroom practices with Thinking Maps® have been effective in supporting student learning of mathematics. This research examined students' perception toward Thinking Maps® in the math classroom. By examining student perception, the researcher was able to examine students' perceived purpose of Thinking Maps and how students used Thinking Maps® in the math classroom. The researcher then compared students' perception with classroom practices to determine if Thinking Maps® is being used and presented in the appropriate manner.

Research Questions

This study was designed to investigate students' perception of Thinking Maps® and the Thinking Maps® Learning Community in the middle school mathematics classroom by answering the following questions:

1. What is students' perception of Thinking Maps® in the math classroom?
2. How do students use Thinking Maps® in the math classroom?

Definition of Terms

- Common Core State Standards (CCSS): Uniform standards developed and adopted by forty-three states. CCSS is a set of clear college- and career-ready standards for kindergarten through 12th grade in English language arts/literacy and mathematics (Common Core, 2015).
- Georgia Milestones Assessment System (GMAS): New standardized test developed by the State of Georgia to be used as end of grade test for third through eighth grade. The GMAS will contain selected response, constructed response, and extended constructed response questions for the Reading/Language Arts and Mathematics sections of the test (Georgia Department of Education Assessment for Learning Series Overview PowerPoint).
- Standards for Mathematical Practice: Eight mathematical practices that students and teachers should use when solving math problems (Georgia Standards, 2015). See Appendix A.
- Thinking Maps®: Eight maps uniform maps developed by David Hyerle to organize all thinking processes (Hyerle, 1994). The eight maps are designed encompass all thinking

processes and are applicable to all age levels and content areas (Hyerle, 1994). See Appendix B.

- Thinking Maps® Learning Community (TMLC): An online electronic platform available for purchase by schools to create and store Thinking Maps® online. The TMLC is available for both teachers and students. The TMLC became active on August 1, 2014. (Thinking Maps, 2015).

Limitations and Delimitations

This study was limited to the eighth grade math students in the researcher's classroom. This study was limited to students' willingness to participate and honest responses to the questionnaires and focus group interviews. The focus group interviews were limited to six students chosen by the researcher and may not be representational of all students' views. In addition, the researcher had no control over accessibility to the electronic platform and malfunctions in the program.

This study was delimited to a rural school in Georgia. Specifically, this study was delimited to eighth grade math students in the researcher's math classroom who have been using Thinking Maps® for two years. Students within other grade levels and schools were not a part of the study.

Significance of Study

The demand for higher order thinking skills in the middle school mathematics classroom and rigorous standardized assessments requires teachers to provide appropriate tools to their students to support these demands. Thinking Maps® is one of many programs available to support higher order thinking skills. This study allowed the researcher to gain a better understanding of students' perception toward Thinking Maps® in the math classroom. This allowed the researcher to determine if Thinking Maps® are being used appropriately. In addition, the researcher examined classroom practices to determine how those practices influenced students' perception.

Summary

New standards and standardized assessments require students to perform at greater levels than ever before. Rote recall assignments and tests are outdated. Students are required to use critical thinking skills to apply and synthesize the basic skills they have learned to new and different situations (Georgia Department of Education Assessment for Learning Series Overview PowerPoint). Thinking Maps® is a tool to organize thinking and supports critical thinking skills (Hyerle, 1994). This study probed to see how students perceived Thinking Maps® in the mathematics classroom to support the critical thinking required for the new curriculum standards and GMAS. The researcher used the results to evaluate classroom practices relating to Thinking Maps® and how those practices influence students' perception of Thinking Maps®.

Chapter 2: Review of Literature

This study explored student perception toward Thinking Maps® in the math classroom and how Thinking Maps® is used in the math classroom. The purpose of the study was to determine if Thinking Maps® provided the support that students need to be successful in mathematics. This chapter examines the relevant literature that consisted of the following: concept maps and Thinking Maps®, concept mapping in mathematics instruction, electronic concept maps construction and research on Thinking Maps®

Concept Maps and Thinking Maps®

Joseph Novak and his team at Cornell University developed concept maps in 1972 to understand how children acquire basic science concepts (Chen & Hu, 2013, p. 210). Since that time, research has been conducted on the use of concept maps in multiple disciplines and all age levels. Although concept maps have been found to be effective in multiple disciplines, this study focused on the effectiveness of concept maps in mathematics.

Concept maps have been found to be beneficial for knowledge acquisition, aiding students' planning activities and monitoring progress (Hagemans, Meij, & Jong, 2012, p. 3). Concept mapping provides a bridge between prior knowledge and targeted knowledge (Marulcu, Karakuyu & Dogan, 2013, p. 612). Since concept maps require students to organize information in meaningful ways, concepts maps provide valuable insight to students' knowledge level as well as the structure of their knowledge (Rosen & Tager, 2014, p. 254; Marulcu, Karakuyu & Dogan, 2013, p. 613). Additionally, concept mapping allows teachers to measure students' critical thinking skills (Yun Soo, 2013, p. 11) since students are required to use higher cognitive functions such as analysis and synthesis and meta-cognitive skills in creating concept maps (Villaon & Calvo, 2011, p. 16).

Concept mapping is intended to be flexible so the same information can be presented in multiple configurations (Hyerle, 1994, p. 116). In contract Thinking Maps®, developed by David Hyerle, do not change to fit specific situations. They consist of eight graphic organizers based on fundamental patterns of thinking (Hyerle, 1994). These visual tools are intended to be used by learners at all age levels to connect, share, and reflect on information (Hyerle, 1994, p. 1). Teachers and students can use Thinking Maps® to assess work and improve thinking abilities (Hyerle, 1994, p. 210). They are based on the model of interrelated thinking processes developed by Albert Upton (Hyerle, 1994, p. 120). These eight maps, either used individually or in combination with each other can be used with any grade level, content and cognitive process. There is no hierarchical order to Thinking Maps® rather the immediate need and/or intended learning outcome determines the map to use. This consistency of map distinguishes Thinking Maps® from concept maps and other graphic organizers.

Concept Maps in Mathematics Instruction

Concept maps can be used to assess students' conceptual understanding, mathematical language fluency, and critical thinking in problem solving (Afamasaga-Fuata'I, 2008, p. 8). Chen and Hu (2013) studied the use of concept maps to dissect a complex problem hierarchically into a set of sub-problems. By understanding the relationship between the original problem and sub-problems, and correctly answering the sub-problems, the student will eventually obtain the answer to the original problem by synthesizing the answers to the sub-problems (Chen & Hu, 2013, p. 210). Chen and Hu (2013) found that applying concept mapping tools significantly improved student performance in answering complex math problems (p. 217). This tool improved mathematical problem-solving skills regardless of knowledge and skill level (Chen & Hu, 2013, p. 217).

Lapp, Nyman, and Berry (2010) investigated how students joined mathematical ideas within their schema of linear algebra concepts (p. 3). After analyzing student created concept maps, they found that students had difficulty making connections between concepts from different clumps (Lapp, Nyman, & Berry, 2010, p. 16).

Electronic Concept Map Construction

The traditional approach to creating concept maps has been with paper and pencil. One drawback to this approach is the difficulty to modify the concept map (Hwang, Wu, & Kuo, 2012, p. 275). As technology has increased within recent years, multiple electronic concept mapping platforms have been developed. Software packages, web based applications and apps for mobile devices have entered the market. Multiple research projects have been conducted to compare the effectiveness of traditional concept map creation to electronic concept maps.

Research by Hwang, Wu, and Ke (2011) showed that use of interactive concept mapping software "enhanced learning attitudes and improved the learning achievements of students" (Hwang, Wu, & Kuo, 2012, p. 275). Kwon and Cifuentes (2009) reported that "computerized collaborative and individual concept mapping had positive effects on students' learning achievements" (Hwang, Wu, & Kuo, 2012, p. 275). Rosen & Tager (2014) also found that students using electronic platforms to create concept maps outperformed students using traditional methods (p. 261). Yun Soo (2013) found that students are more likely to learn, integrate and organize the knowledge when concept mapping is integrated with technology (p. 10).

Research on Thinking Maps®

There is limited formal literature about Thinking Maps®. Several studies that were investigated in this section consist largely of doctoral dissertations. Although Thinking Maps® is the central use in each of these studies, the learning outcomes of the studies varies from student achievement, reading comprehension, higher order thinking skills and ELL literary language acquisition. No studies were found that examined students' perception toward Thinking Maps®.

Effectiveness of Thinking Maps® assessed through writing. Sunseri (2011) investigated the impact of Thinking Maps® on elementary students' expository composition and students' perception of Thinking Maps® in the writing process (p. 65). Sunseri (2011) found that students that wrote using Thinking Maps® to guide the writing process actually scored lower on the writing assignments than students in the control group that used a different form of graphic organization for writing (p. 69). In contrast, during the student interview, the students stated that they believe that Thinking Maps® helped them (Sunseri, 2011, p. 85). The study also found the writing scores of ELL students fell less drastically than non-ELL students, indicating that Thinking Maps® may benefit ELL students (Sunseri, 95-96).

Lopez (2011) compared the use of Thinking Maps® on the academic language development of English Language Learners. Through surveys and interviews, Lopez investigated the impact of Thinking Maps® for ELL students. Lopez (2011) found that Thinking Maps® directly supported academic learning among ELLs (p. 90).

Weiss (2011) conducted similar research using Advanced Placement Environmental Science students. Students were given an essay that required them to compare and contrast a science concept. After this essay, students received instruction in using Thinking Maps® to compare and contrast and were given assigns that required the students to complete double bubble maps. At the end of the study, students were given another essay that required comparing and contrasting. The essay comparisons indicated that 45% more students could compare and contrast in an essay after instruction in Thinking Maps® (Weiss, 2011, p. 33). Interestingly, students' reception to Thinking Maps® varied greatly in this study (Weiss, 2011, p. 35).

Effectiveness as Measured to Standardized Test. Several studies have been conducted to determine the effectiveness of Thinking Maps® as measured by state standardized test scores. Hickie (2006) examined tests scores of three Tennessee elementary schools after two years of implementation of Thinking Maps®. When comparing scores of the same students prior to the implementation of Thinking Maps® and scores two years later, there was a significant difference in the mean reading score and not mean math score (Hickie, 2006, p. 97). Diaz (2010) conducted a similar study comparing state test scores of two urban middle schools in Florida. This study compared students' scores who had received three years of Thinking Maps® instruction. Diaz (2010) findings concluded that there was no significant increase in test scores in the school that received Thinking Maps® instruction for reading or math (p. 79-82). Additionally, there was no significant difference between test scores of the school that implemented Thinking Maps® and the control school. Similarly, Leary (1999) compared the standardized test scores of fourth-grade classrooms in two schools. He found that there was no significant difference between test scores between the treatment and control schools.

Teacher Perception of Thinking Maps®. Edwards (2011) conducted research to determine teacher perception of Thinking Maps® and to examine the effectiveness Thinking Maps® in reading comprehension of elementary students with disabilities. Based on teacher perception surveys, most teachers believed that Thinking Maps® improved understanding of concepts being taught, improved critical thinking, comprehension, is a springboard for writing and students' attitude toward reading (Edwards, 2011, p. 241-242, 244-245). Interestingly, teachers tended to avoid the maps that required higher cognitive process, such as the Multi-Flow map and Bridge Map (Edwards, 2011, p. 242-243).

Thinking Maps® Software. Often Thinking Maps® are generated by students by hand. Occasionally, map templates are used, but this is discouraged because it limits student thinking. Thinking Maps® developed software for teachers to use to create Thinking Maps® on the computer. This software is often limited to the teacher computer and unavailable to students. In August 2014, Thinking Maps® unveiled the TMLC. When schools purchase the TMLC, both teachers and students have individual accounts. The TMLC allows students to create, edit, save and share Thinking Maps®. The application also includes a writing window for students to use to write using the information on the map.

Summary

Organizing thinking is a critical skill for today's learners. The ability to think critically is important in our world of complex problems. Concept mapping is one form of organizing thought. Concept mapping has been found to be an effective tool in an educational setting. In the math classroom, concept mapping has been proven to support complex problem solving and evaluating student understanding. Software, web based programs, and mobile apps have been developed to facilitate the construction of concept maps. These electronic platforms have proven to be more effective in supporting student engagement, analysis and revision of concept maps Hwang, Wu, & Kuo, 2012; Rosen & Tager, 2014).

Thinking Maps® were developed by David Hyerle to simplify thinking processes to eight visual representations (Hyerle, 1994). Much like concept maps, they support knowledge construction and analysis of knowledge. In contrast to concept maps, Thinking Maps® are limited to eight representations that encompass all thought process across content and grade level. Much of the literature found on Thinking Maps® focused on the effectiveness of Thinking Maps® by measuring student achievement on standardized test or pre-test and post-test analysis.

There is limited research in examining students' perception toward concept mapping. The literature does indicate that students that use electronic concept mapping software have enhance learning attitudes and willingness to learn (Hwang, Wu, & Kuo, 2012; Rosen & Tager, 2014). There is a significant gap in the literature on examining students' perceptive toward using Thinking Maps®.

Chapter 3: Methodology

The purpose and nature of this study was to explore students' use and perception of Thinking Maps® in the middle school math classroom. In addition, this study explored students' perception toward the use of the electronic Thinking Maps® platform (TMLC). The methodology used to explore students' perception of Thinking Maps® is described in this chapter. The research design, selection of participants, data collection and data analysis procedures are described.

Research Design

This study used a qualitative case study research design. A case study design focuses on a specific program, event or activity (Creswell, 2012). In addition, a case study is bounded in terms of time, place or some other characteristic (Creswell, 2012). The primary focus of this research is qualitatively to evaluate students' perception of Thinking Maps®. This study is bound by eighth grade students in the researcher's math classroom that have used Thinking Maps® for at least one year. In addition to the qualitative data, survey data was collected through a questionnaire to enrich the findings of the qualitative data. Data collected for this study are designed to answer the research questions:

1. What is students' perception of Thinking Maps® in the math classroom?
2. How do students use Thinking Maps® in the math classroom?

Data was collected through focus group interviews, classroom observations and a survey. Survey data was collected through a nineteen item questionnaire open to all eighth grade students. The questionnaire examined students' perception toward who is creating the Thinking Maps®, how useful students feel Thinking Maps® are to support mathematical reasoning and how useful students perceive specific Thinking Maps®. Qualitative data was collected through focus group interviews and classroom observations. Focus group interviews were conducted to gain a deeper insight to student perception. The classroom observations were conducted while students are using the TMLC.

Participants

This study involved students taking eighth grade CCGPS mathematics at a rural middle school in Northwest Georgia. All selected participants had at least one year of experience using Thinking Maps®. For the focus group interview portion of the study, six participants were selected to complete interviews about their perception of Thinking Maps® in the middle school math classroom. Sampling selection used maximal variation sampling to try to include as many of the school subgroups as possible. Maximal variation sampling is used to gain multiple perspectives of individuals by sampling individuals with differing characteristics (Creswell, 2012). The sample included a male and female participant for the following categories: African American, Caucasian, and students served in the special education program for specific learning disability in math or reading comprehension. Participants were selected by the researcher and asked if they would consent to participate in the study. Participants and a guardian signed a consent form (Appendix C).

Table 1.
Interview Participant Demographics

Pseudonym	Gender	Ethnicity	Student With Disability
AH	Female	Caucasian	No
BH	Male	African American	No
CB	Female	African American	No
BP	Male	Caucasian	No
WE	Male	Caucasian	Yes
BK	Female	Caucasian	Yes

For the survey, all eighth grade students were invited to participate. Participation was voluntary and 57 students participated in the survey. The survey did not ask the participant to identify if they were served in the special education program and since the surveys were anonymous the researcher was not able to identify the percentage of the survey population served in special education. In addition, after the survey many of the Caucasian students indicated that they did not know what "Caucasian" meant and put "other" for ethnicity; thus, the "other" subgroup has an unusually high number of students.

Table 2.
Survey Participant Demographics

Gender	Caucasian	African American	Hispanic	Other	Total
Female	10	2	0	21	33
Male	11	4	2	7	24

Total	21	6	2	28	57

Research Context

This study involved eighth grade students in the researcher's classroom. Surveys were conducted during class time. Focus group interviews were conducted in the math classroom outside of the participants' class period. No other individuals were present for the interviews other than the participants and the interviewer. Observations were conducted during each of the three math classes over a period of several weeks.

Researcher Background and Role

Due to the multiple modes of data collection, the researcher had different roles during the research process. The researcher had to be careful to not use biased or subjective questions to lead the participants to give construed responses. The researcher is a supporter of Thinking Maps® and has the most Thinking Maps® training within the school. As a result, the researcher had to be openminded as as not to interpret the results in favor of Thinking Maps® if the data does not positively support Thinking Maps®. In addition, the researcher had to look objectively at classroom practices to determine how those practices influenced students' perception toward Thinking Maps®.

Classroom observations posed the most difficult for the researcher to perform objectively. Since the researcher is also the classroom teacher, the researcher had to be careful to make appropriate observations that relate to student use and perception of Thinking Maps® without including bias in the observations. The researcher developed an observation form to help overcome bias in the observations.

Data Collection

The purpose of this research was to determine students' perception toward and use of Thinking Maps® in the middle school math classroom. Three sources of data were collected for this study over a period of six weeks, from January 29, 2015 to March 12, 2015. Informed consent forms were given to the focus group participants and surveys were conducted during the first week. Focus group interviews were conducted during the second week. Classroom observations were conducted over the remaining four weeks.

Survey. The survey was open to all eighth grade students. Sixty-nine percent of the eighth grade students volunteered to complete the survey. The 19 item questionnaire was created in Google Forms and the URL was provided to students (Appendix D). The first section of the survey asked for demographic information about the participants such as gender and ethnicity. The second section of the survey asked students to state the percentage of time that Thinking Maps® were generated by different groups in the math classroom. The third section of the survey used a Likert scale to identify how beneficial students felt Thinking Maps® were for various activities in the math classroom, such as note taking, solving problems, etc., and how beneficial they felt each specific map was in the math classroom.

Interviews. Interviews were conducted to gain a deeper understanding of students' perception toward using Thinking Maps® in the math classroom. Ten students were invited to participate in a focus group. Six students completed the consent form to participate in the focus group study. Students were interviewed in pairs. Interviews were conducted in the math classroom during the researcher's planning periods.

An interview protocol was developed before the interview session (Appendix E).

Students were asked to tell how Thinking Maps® are used in the math classroom. In addition, students were asked to tell about their experiences using Thinking Maps®, both positive and negative. Also, students were asked about their perception toward using the electronic platform to create Thinking Maps®.

Observations. Classroom observations were completed by the researcher to determine students' perception and ease of use of the TMLC. Observations focused on the ease of use of the electronic platform. The researcher observed and noted difficulties, student reactions, preferences that students experience while learning and using the electronic platform using the observation form (Appendix F). This information also included the number of students that were not able to successfully complete a Thinking Map using the electronic platform. Three observations were completed over the course of four weeks.

Data Analysis Procedures

This research study incorporated a combination of qualitative and survey data for analysis. The primary focus is on the qualitative research while the survey was used to support the qualitative data.

Qualitative Phase. The purpose of the focus group interviews was to investigate students' perception toward Thinking Maps® in the middle school. The researcher used Creswell's (2012) six steps for coding the data (p. 244-245). All transcripts were read to get a sense of the whole picture. The researcher recognized three emerging themes. Each interview was individually coded based on positive feelings toward Thinking Maps®, negative feelings toward Thinking Maps®, and perception toward using the electronic Thinking Maps® platform (Appendix G). Later, the interviews were reexamined to code for two additional categories:

purpose and use of Thinking Maps® and specific maps that students mentioned that supported learning math. A codebook was developed to list themes, indicators, and rules (Appendix H). After each interview was coded, the interviews were combined and organized by question to compare student responses and determine emerging themes of the data (Appendix I). The same coding method was also used to code classroom observation three (Appendix J).

Surveys. The purpose of the survey data is to support the data obtained from the focus group interviews. The data was organized to show the number of students that selected each response for each question (Appendix K). Next the researcher computed the percentage of students that fell in each category. The percentage of students that positively supported each question was compared with the qualitative data to determine if the survey data was consistent or inconsistent with the qualitative data.

Credibility and Consistency

Multiple measures were used to ensure that data is creditable. This research used triangulation by collecting and converging different kinds of data on the same phenomenon (Creswell, 2012, p. 536). Triangulation uses different individuals, data types and data collection methods to validate the evidence (Creswell, 2012). The researcher triangulated the data by collecting data from multiple sources: student surveys, focus group interviews and classroom observations. By comparing the multiple forms of data, the researcher had multiple sources to support the emerging themes. In addition, the researcher used member checking, by submitting draft transcripts to participants for review, to ensure that interviews and observations are accurate and the report is fair and representative of their perceptions. All participants read the transcripts and verified that all information was accurate. After the interviews and observations were coded, the findings were also peer reviewed by the research partner to ensure that all emerging themes were accurate and themes were not overlooked.

Ethical Considerations

Participants represent a sample of the population that is receiving instruction on the TMLC in a middle school math classroom. All names of participants remained confidential and results from the surveys and interviews did not affect the students' academic standing in the class. Prospective participants were asked to complete consent forms prior to the qualitative instrument being administered. They were informed of the procedures required for their participation and that participation is voluntary. Participants had the right to drop out of the study at any time without loss of benefits already afforded to them. Additionally, participants had the right to ask that the audio recording be stopped at any time. All data is maintained in the researcher's home in a locked file. Data will be destroyed/shredded three years after completion of the project.

Summary

This study was designed to provide insight into students' perception of Thinking Maps® in the middle school math classroom. Through a qualitative case study design, the researcher was able to collect in depth data to analyze and evaluate to determine students' perception toward Thinking Maps® in the math classroom. The interview data was coded and analyzed to determine emerging themes. In addition, survey data was used to enhance the qualitative data. The results of the data analysis are discussed in the next chapter.

Chapter 4: Results

Concept mapping has been used since the early 1970s to organize thinking and support higher order thinking (Chen & Hu, 2013). David Hyerle developed a set of eight concept maps that support all form of higher order thinking (Hyerle, 1994). These specific maps are intended to be used by learners in all age levels and content areas to support thinking (Hyerle, 1994).

Thinking Maps® was introduced into the researcher's school district in 2012 and integrated into the school improvement plan initiatives in for the 2013-2014 school year. A digital version Thinking Maps® was introduced in the 2014-2015 school year. Teachers and students have been using Thinking Maps® for almost two years.

This study was designed to examine students' perception toward the use and purpose of Thinking Maps® in the middle school math classroom. In addition, the researcher was interested in examining students' perception toward using the Thinking Maps® electronic platform to generate maps in the math classroom. Finally, the researcher examined how students' perception relates to classroom practices and the implications of students' perception toward Thinking Maps®.

This section examines the results of the data collected for this study. The qualitative and survey data results are analyzed separately. In the discussion section, the results of the qualitative and survey data are compared. A discussion about classroom implication is included.

Qualitative Data Results

From the interview responses, students' reactions toward Thinking Maps® were mixed. Students overwhelmingly perceive Thinking Maps® simply as a tool for taking notes and their response was based on whether or not they liked to use Thinking Maps® for taking notes.

Student responses included “it’s easier writing notes in Thinking Maps®,” and “they are better than regular note taking” while other students simply stated “I hate taking notes in math with thinking maps” and “I don’t really like using them that much” (Interviews, Appendix G). Students commented that Thinking Maps® help to break problems down, allows students to see the problem better, and understand what the problem is asking. Students used phrases such as “it breaks it up,” “see it better,” and “understand it better” (Interviews, Appendix G).

When asked about their experiences with Thinking Maps, the students were not able to recall a negative experience with using Thinking Maps® in math. Students were able to list several maps that have been useful in math. Students mentioned the flow map, circle map, and brace map for breaking down problems and understanding math concepts (Interviews, Appendix G).

Students were very much interested in using an electronic platform to create Thinking Maps®. Students’ desires to use an electronic version centered on the fact that they do not like constructing the maps because many of them are particular about having perfectly shaped circles and squares. Observation 3 validated this claim since students were able to successfully create Thinking Maps® on the electronic platform without having to worry about creating the shapes (Appendix J). This feature was the one thing on which students repeatedly commented. The electronic platform allowed students to focus less on the construction of the map itself and focus on the content of the map.

Survey Data Results

Overall student survey responses were favorable toward using Thinking Maps® and perceived that Thinking Maps® were beneficial for solving problems, writing explanations and using higher order thinking skills (Table 3). For all maps except the multi-flow map and double-bubble map, over 50% of the respondents stated that the map was beneficial in the math classroom (Table 3). The multi-flow map represents cause and effect and the double-bubble map is used to compare and contrast, both concepts are not frequently used in math (Appendix B).

Table 3.

Survey Results for Student Perception Questions(Percentage)

Survey question	Strongly Disagree/ Disagree	Neutral	Strongly Agree/ Agree
How do you agree with the following statement: Thinking Maps® are beneficial for taking notes in the math classroom.	1.7%	13.6%	66.7%
How do you agree with the following statement: Thinking Maps® are beneficial for solving problems in the math classroom.	19.3%	26.3%	54.4%
How do you agree with the following statement: Thinking Maps® are beneficial for answering critical thinking questions in the math classroom.	8.8%	26.3%	64.9%
How do you agree with the following statement: Thinking Maps® are beneficial for writing explanations in the math classroom.	3.5%	36.8%	57.9%
How do you agree with the following statement: The Circle Map is useful in the math classroom.	1.8%	35.1%	63.2%
How do you agree with the following statement: The Bubble Map is useful in the math classroom.	7.0%	28.1%	64.9%
How do you agree with the following statement: The Double Bubble Map is useful in the math classroom.	12.3%	38.6%	48.1%
How do you agree with the following statement: The Tree Map is useful in the math classroom.	7.1%	28.6%	64.3%
How do you agree with the following statement: The Flow Map is useful in the math classroom.	12.5%	33.9%	53.6%
How do you agree with the following statement: The Brace Map is useful in the math classroom.	17.5%	26.3%	56.1%
How do you agree with the following statement: The MultiFlow Map is useful in the math classroom.	26.3%	35.1%	38.6%

How do you agree with the following statement: The Bridge Map is useful in the math classroom.	16.1%	33.9%	50%

Students overwhelmingly indicated that Thinking Maps were generated by the teacher at least 50% of the time (Table 4). In addition, the students indicated that they rarely create a Thinking Map® without being prompted by the teacher.

Table 4.
Survey Results for Map Generation(Percentage)

Survey question	<50%	50%	>50%
What percent of the time are Thinking Maps® generated by the teacher in your math classroom?	29.9%	38.5%	31.6%
What percent of the time are Thinking Maps® generated in small groups in your math classroom?	59.6%	21.1%	19.3%
What percent of the time are Thinking Maps® generated individually in your math classroom?	57.9%	15.8%	26.3%
What percent of the time do you create Thinking Maps® in your math classroom without being prompted by your teacher?	78.9%	8.8%	12.3%
What percent of the time do you create Thinking Maps® using the electronic platform?	54.4%	19.3%	26.3%

Discussion

Students view Thinking Maps® primarily as a note taking tool, but they were able to use the notes to solve math problems. This is consistent with the survey data in which 66.7% of the students perceive that Thinking Maps® are beneficial for taking notes. In conjunction with this, 71% of the students indicate that the Thinking Maps® are generated by the teacher at least 50% of the time. This indicates that the teacher often used Thinking Maps® as a note taking tool and provided the students with the information needed to complete the maps.

The interview data indicated that students had mixed feelings toward using Thinking Maps® to take notes. Regardless of their feelings, most of the students perceived the benefits of using Thinking Maps®. Students recognized that Thinking Maps® helped them solve math problems, break problems down and make problems easier to understand. The data from the survey is consistent with the interview data with 54.4% of students agreeing or strongly agreeing that Thinking Maps® is beneficial for solving math problems and 64.9% of the students agreeing or strongly agreeing that Thinking Maps® are beneficial for answering critical thinking questions.

Additionally, students were very interested in the electronic platform of Thinking Maps that allows the students to focus less on the map construction. This is further supported by Observation 3.

Originally, the researcher was surprised by the results of the interviews and surveys, specifically that students perceive Thinking Maps® as a note taking tool. The intent was to use Thinking Maps® as a tool for solving problems in the math classroom. In contrast, the students perceived it as notes. In reviewing classroom practices, Thinking Maps® was often presented as an organizational tool for notes. Often the flow map is used to write out sequences or steps for solving specific problems. The brace map is used to break formulas and word problems into parts. Tree maps are used to categorize and organize concepts. Although the intent and perception differed, ultimately students were about to use these maps as resources for solving problems and higher order thinking questions (Interview responses and Table 3).

Survey data also indicated that Thinking Maps® were generated primarily by the teacher. This is not surprising since Thinking Maps® are often presented as notes. The teacher is organizing the thinking for the students instead of the students organizing their own thinking. A classroom implication is that method of delivery needs to change, so that students are generating the maps more often independent of the teacher.

In addition, the electronic platform could be highly beneficial to students. As indicated by the interviews, students are very interested in using the electronic platform. This positive response is supported by Observation 3. The electronic platform reduces the students' focus on the map creation and allows the students to focus on the content for the maps.

Conclusion

Based on the data collected from the surveys, focus group interviews and classroom observations, students are favorable to using Thinking Maps® in the middle school math classroom. Students perceive positive benefits of using Thinking Maps. In addition, students are favorable to the electronic platform to create maps. Students overwhelmingly use Thinking Maps® as a note taking tool. They are able to use their notes, the Thinking Maps®, to breakdown math problems and determine what the question is asking. Students view the teacher as the primary source for the information to be included in the map.

The review of literature found that concept mapping has been found to be beneficial for knowledge acquisition (Hagemans, Meij, & Jong, 2012). In addition, concept mapping provides a bridge between prior knowledge and targeted knowledge (Marulcu, Karakuyu & Dogan, 2013).

Also, applying concept mapping tools significantly improved student performance in answering complex math problems (Chen and Hu, 2013). The findings of this research indicate that students are using Thinking Maps® for knowledge acquisition, namely in the form of note taking. In addition, Thinking Maps® provide a bridge between prior knowledge and targeted knowledge by breaking problems down into parts that the students can understand. Finally, students report that Thinking Maps® helped them answer complex math problems by breaking the problems into smaller parts and showing the steps to solve problems.

The findings of this research should be used to guide teacher practices. Thinking Maps® provide students with necessary supports to breakdown problems and determine the steps to solve problems. Thinking Maps® are beneficial to students as a note taking tool. The teacher needs to find a way to support students to use the maps without being the primary source of information.

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APPENDIX A

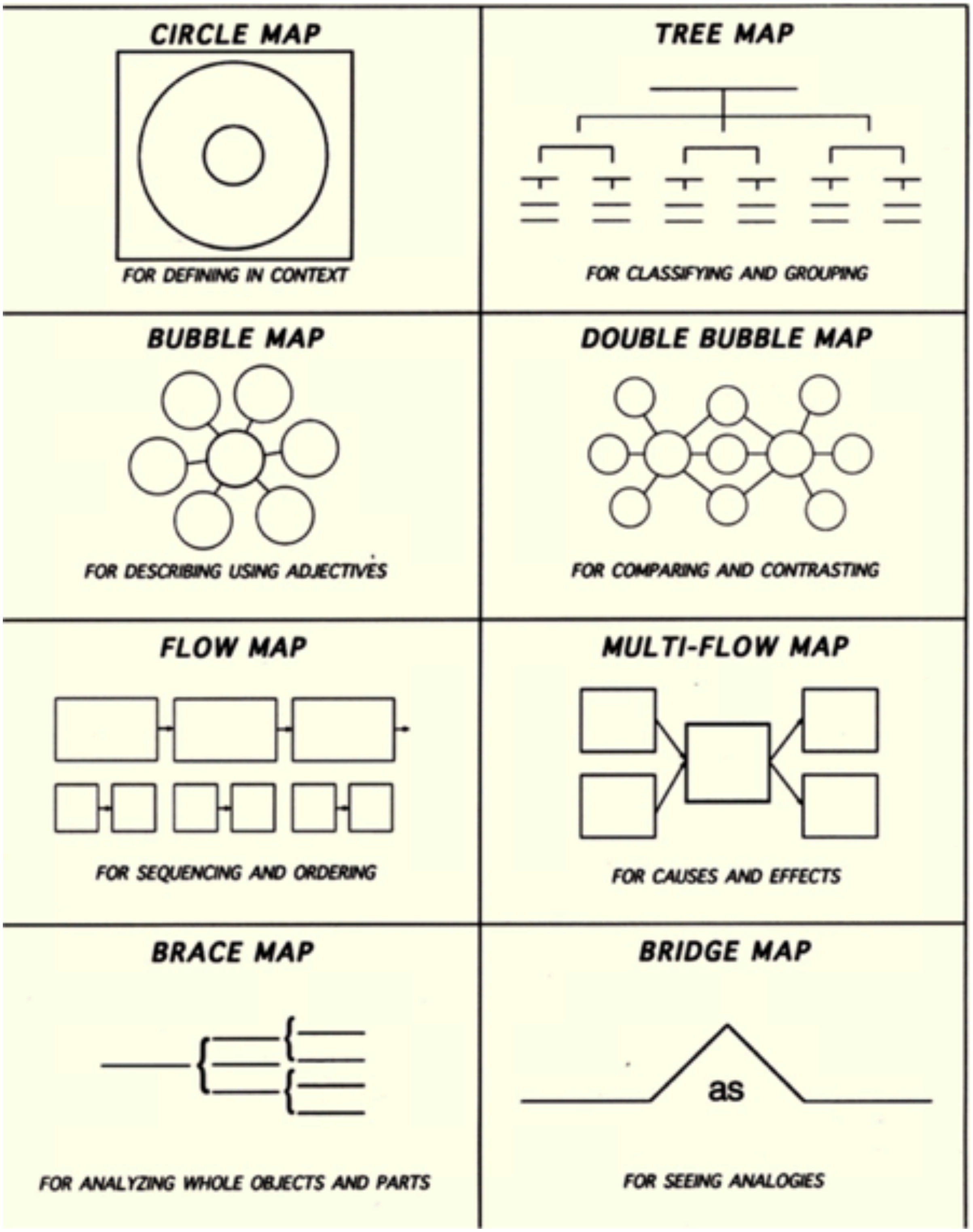
Standards for Mathematical Practice

Mathematical Practices

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

APPENDIX B

Thinking Maps®



Appendix C

Consent Form for Participation in a Research Study

An Evaluation of Students' Perception of Thinking Maps® in the Middle School Mathematics Classroom

Description of the research and your participation

You are invited to participate in a research study conducted by Heather Morse. The purpose of this research is the examine students' perception of Thinking Maps® in the mathematics classroom. Thinking Maps® have been used at the school for several years now. Thinking Maps® has recently developed an online program for generating the maps. The purpose of this study is to examine the impact of the online program on students' perception of Thinking Maps®.

Your participation will involve completing an open response questionnaire at the beginning and end of the study and participating in small group interviews to discuss Thinking Maps® in math. All students, whether in the study or not, will receive training on the online Thinking Maps® program. Those involved in the study will provide specific feedback about the program.

Risks and discomforts

There are no known risks associated with this research.

Potential benefits

There are no known benefits to you that will result from your participation in this research. This research will help me understand students' perception of Thinking Maps® in the math classroom and the influence of the online program on students' perception.

Protection of confidentiality

Students' identity will remain confidential in the reporting of this study. Responses to the questionnaire and small group interviews will remain confidential and will not impact the academic performance of the participants. Small group interviews will be audio recorded for transcribing purposes only. Participants have the right to request that the recorded be stopped at any time.

Voluntary participation

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

Contact information

If you have any questions or concerns about this study or if any problems arise, please contact Heather Morse at 770.834.3389.

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant's signature____________________________________ Date: ____________________

Guardian's signature______________________________________ Date: ____________________

A copy of this consent form should be given to you.

APPENDIX D

Questionnaire

Research Question: How are Thinking Maps® used in the middle school math classroom?

1. Gender
    - Male
    - Female

2. Ethnicity
    - African American
    - Caucasian
    - Hispanic
    - Other

3. What percent of the time are Thinking Maps® generated by the teacher in your math classroom?
   (0%, 25%, 50%, 75% or 100%)

4. What percent of the time are Thinking Maps® generated in small groups in your math classroom?
   (0%, 25%, 50%, 75% or 100%)

5. What percent of the time are Thinking Maps® generated individually in your math classroom?
   (0%, 25%, 50%, 75% or 100%)

6. What percent of the time do you create Thinking Maps® in your math classroom without being prompted by your teacher?
   (0%, 25%, 50%, 75% or 100%)

7. What percent of the time do you create Thinking Maps® using the electronic platform?
   (0%, 25%, 50%, 75% or 100%)

Using the scale below, how do you agree with the statement

8. Thinking Maps® are beneficial for taking notes in the math classroom.
   (Strongly disagree, disagree, neutral, agree, strongly agree)

9. Thinking Maps® are beneficial for solving problems in the math classroom.
   (Strongly disagree, disagree, neutral, agree, strongly agree)

10. Thinking Maps® are beneficial for answering critical thinking questions in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

11. Thinking Maps® are beneficial for writing explanations in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

12. The Circle Map is useful in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

13. The Bubble Map is useful in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

14. The Double Bubble Map is useful in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

15. The Tree Map is useful in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

16. The Flow Map is useful in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

17. The Brace Map is useful in the math classroom.
    (Strongly disagree, disagree, neutral, agree, strongly agree)

18. The Multiflow Map is useful in the math classroom.

(Strongly disagree, disagree, neutral, agree, strongly agree)

19. The Bridge Map is useful in the math classroom.
(Strongly disagree, disagree, neutral, agree, strongly agree)

APPENDIX E

Project: An Evaluation of Students' Perception And Use of Thinking Maps® in the Middle School Mathematics Classroom

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Time of Interview:
Date:
Place: Classroom
Interviewer: Heather Morse
Interviewee:
Position of Interviewee: 8th Grade student

The purpose of this interview is to examine your perception of Thinking Maps® in the mathematics classroom. You have already participated in an online survey to collect data for this. This interview is to develop a deeper understanding of your perception. This interview is being audio recorded. I will transcribe the interview and study your responses. As you have already been informed this interview is confidential and in no way affects your grade in my class. This interview will last about 10 minutes. [Students and parents have already signed consent forms prior to the interviews.]

Questions:

1. Demographic Questions (I will probably not ask students this question. All the students participating in the interviews are current 8th grade students in my classroom. I will have access to their demographic information.)
2. Can you tell me about using Thinking Maps® in the math classroom?
3. What has been your experience with using Thinking Maps® in the math classroom? (Prompts: Such as, how you used Thinking Maps®? Have your experiences been positive or negative? Can you think of a time you had a good experience with Thinking Maps®? Can you think of a time you had a bad experience with Thinking Maps®?)
4. In your opinion, what is the purpose of Thinking Maps® in math classroom?
5. How do you feel about using Thinking Maps® in the math classroom?
6. When you hear your teacher mention Thinking Maps® what is your reaction?
7. If you could use generate the Thinking Maps® on the computer, would you rather use the computer than paper? Why or why not?

Thank you again for your time and help. Again all responses are confidential and will not affect your grade.

Appendix F

Fieldnotes for Observations of Students Using the Thinking Maps electronic platform

Research Question: What is students' perception of Thinking Maps® in the math classroom? (These observations focus specifically on students' perception of using the electronic Thinking Maps® platform the generate maps)

Date:
Class period:
Type(s) of map created:
Who determined the type of map and the information to be recorded on the map?

Descriptive	Reflective
Student Reactions:	
Student Difficulties:	
Student Successes:	
No. of students not able to complete the Thinking Map in the given time period	Possible Reasons

Appendix G

Interview 1: BH and AH

Interviewer: You agreed to meet with me to discuss Thinking Maps in the math classroom. I have six questions to ask you and I just want you to know that I am your math teacher, but I want your true honest opinion about everything I ask you about Thinking Maps. It will not ever count against your grade, whatever you say. And I am recording this, but everything that I do, I have type out everything we saw. I will give you a copy of it and if I wrote something wrong or anything like that I will correct it, because that is part of my research, I have to analyze everything that you say. There are six of you that turned in your forms, so I decided to partner you up and I think I will partner the others up as well. I do want your honest opinion. You all have signed consent forms, so that has already been taken care of. Don't be scared or anything like that.

First thing, can you tell me about using Thinking Maps in the math classroom?

AH: Like what do you mean?

Interviewer: Ok so like how and when have you used Thinking Maps?

BH: Say about seventh, sixth grade.

Interviewer: Do you like using Thinking Maps in the math classroom?

AH: Yeah. It's easier to understand. It's easier writing notes in Thinking Maps.

Interviewer: So have you had good experiences using the Thinking Maps?

AH: Yeah.

Interviewer: Has there ever been a time that you had a bad experience using Thinking Maps in math?

AH: Oh no, not in math, not in math. Coach Ballew's I have.

BH: I just got problems with certain maps.

AH: Drawing

Interviewer: Which maps do you have a hard time with in math?

AH: The double bubble.

Interviewer: The double bubble?

AH: I don't like drawing it.

Interviewer: Just the mere fact of drawing it or is it putting the information in it?

AH: Yeah its drawing it.

Interviewer: Ok, so it's just a matter of drawing it that's the problem?

AH: Um Hum.

BH: Sequences. Sometimes sequences because we like rarely do it in here. That's the one that I struggle with.

AH: BH we use that one all the time, child.

BH: No we use….

AH: We use sequencing.

BH: No we use bubble. We use sequence, um no wonder I do bad with stuff. That's the one I struggle with.

Interviewer: In your opinion, what is the purpose of Thinking Maps in math?

AH: For taking notes.

BH: To like divide certain ideas that you have.

AH: Um hum.

BH: So you can like see it better and like understand it better.

Interview: How do you feel about using Thinking Maps?

BH: I like them.

AH: I like them. I like them more than taking notes.

Interviewer: So when you hear me say we're going to making a Thinking Map, what's your first reaction?

BH: I mean nothing really. Just get it done.

AH: Get a piece of paper out. My first reaction is to get a piece of paper out. It's easier. I like using Thinking Maps more.

Interviewer: Ok. If you could do them on a computer, I know we do them on the iPad and the template is still that, but it is still like doing them on paper. If you could do it on the computer were it would make the bubble, fix them and everything for you, would you rather do the computer?

AH: Yeah.

BH: I wouldn't because I would like have to get used to it because I am used to drawing it on the iPads and on computers you have to resize the bubbles and stuff like that.

Interviewer: But if it automatically sized it for you, would you like it?

AH: Yeah. It would be easier because you wouldn't have to get confused with drawing it.

Interviewer: Anything else you want to add?

BH: Let's work.

AH: Um hum

Interviewer: Ok. Well that's all my questions.

Negative feeling toward Thinking Maps

Positive feeling toward Thinking Maps

Use/purpose of Thinking Maps

Specific maps that support learning math

Perception toward electronic Thinking Maps

Interview 1 with BP and CB

Interview: You know that I asked both of you if you were interesting in talking to me about Thinking Maps in the math classroom. And you both said that you were. You both did a survey last week. So today I am just talking to those that agreed and signed the consent form and asking you questions. I am recording this, just audio, because I have to transcribe or type out everything that we say. And I am going to give a copy of it to each of you to make sure it is accurate. It keeps me from having to write a ton of notes while we are talking. I will use that to do the analysis that I have to do for my college class. I am really just trying to get your opinion of what Thinking Maps is like in the math classroom. So you can draw on your experiences from my class, you can draw on your experiences from last year, if you use them in connections math or anywhere else you can refer to that, but don't think about what you do with them in social studies or science or anything else. Also, you are both in my students, but whatever you say today, positive or negative, will not in any way affect your grade or my opinion of you. So I want you to be completely honest. If you think Thinking Maps is the stupidest thing in the world I want you to tell me that. If you think it is the greatest thing since sliced bread I want you to tell me that. Just be honest. It does not affect your grade. I'm just trying to get your idea of Thinking Maps. Does that all make sense? These interviews are not shared with anyone but me and my college professor so not even will Ms. Robison, although I might talk to her about in general what you said but not necessarily what you said specifically. It is not going to be broadcast all over the place. It is confidential and again it does not affect your grade. Any questions?

First question, can you tell me about using Thinking Maps in the math classroom?

BP: They are better than regular note taking because you don't have to really write as much especially with the technology. I like that but it's still notes, so….

CB: I hate taking notes in math with thinking maps.

Interviewer: Why?

CB: I don't know. It's just a lot harder because math is like, it's more of like problems and like word problems.

Interviewer: Ok. Do you feel a connection between the maps and doing the problems?

CB: Yes.

Interviewer: What about what have been some of your experiences been with using Thinking Maps in math? Have you had good experiences?

CB: Yes.

BP: Yes.

Interviewer: Ok tell me about a time or a map or something that has been good for math.

CB: Taking the notes for slope and stuff.

BP: Doing the double bubbles , no the circle maps for the volumes and formulas and stuff.

Interviewer: Ok, have you had a bad experience with using Thinking Maps in math.

CB: No.

BP: No.

Interviewer: What about…in your opinion was is the purpose of Thinking Maps in math?

CB: To help you understand like the way that the problems are supposed to be.

BP: Making it easier to take notes.

Interviewer: Making it easier to take notes?

BP: Yes

Interviewer: How do you feel about using Thinking Maps? Do you like using Thinking Maps? Do you hate using Thinking Maps? How do you feel about them?

CB: Sometimes I do but then sometimes I don't. Because some times its pointless and I don't understand it and sometimes I do.

BP: I like it because it's fun. Something different than just the usual taking notes.

Interviewer: Do you feel like, because you said sometimes its pointless, do you feel like if it was done in a reverse order like maybe you were presented with a problem and then a map that it would make more sense than instead of here's the map and here's a problem, use the map to do the problem?

CB: Yes.

Interviewer: When you hear your teacher say you are going to do a Thinking Map, what is your reaction?

CB: I don't like it.

BP: Great.

Interviewer: Great as in a sarcastic way?

BP: Yeah.

Interviewer: What about if you could…I know we use the iPads and we do them electronically on the iPads it's still just a template and it's just like doing it on paper and pencil, but if you had a computer program that you could use to make the Thinking Maps where it actually created the bubbles for you, do you think you would like that better than just the pencil/paper kind of way of making them?

CB: Yeah. Because I'm like OCD, so I have to make sure my circles are right and everything.

Interviewer: So you think you would as well BP?

BP: Yeah.

Interviewer: I going to ask you again, because pretty soon that is what you are going to do. That's all my questions. Do you have any other questions or comments that you would like to say about Thinking Maps?

BP: No.

CB: No.

Negative feeling toward Thinking Maps

Positive feeling toward Thinking Maps

Use/purpose of Thinking Maps

Specific maps that support learning math

Perception toward electronic Thinking Maps

Interview 1: BK and WE

Interviewer: I am recording this. I that that I told you on the letter that I would be recording it. It's not videoing you at all and I just turned it (the iPad) upside down because I think the speaker is on the bottom side. As you know, I asked you if you would be interested in just talking to me and giving me some more specific details about your opinions and feelings about using Thinking Maps in math. And you can draw on not just the experiences in my class using Thinking Maps, but if you used them in seventh grade, if you used them in your connections math class, anything like that, think about all those experiences. Also you are my students, but whatever you say here about Thinking Maps will not affect your grade in any way. I want you to be completely honest about what you feel and think and don't think that I'm not to hold it against you whether you like it or you don't. So just please be honest with that. And this is confidential. I will type up the recording of us talking today and I will actually give you a copy of it and that you way you can read through it and make sure I put everything down correctly. But it is really just for me and my professor for my college research. If I share any of it with Mrs. Robison (the principal) it will be much more in a general sense. "Hey this is what my students me." It won't be your names or anything like that. It won't be published all over the school website. So you don't have to worry about that. And again it won't affect your grade in any way.

Can you tell my about using Thinking Maps in math?

BK: To me they are like easier to do than writing all these notes down because it like breaks it up.

WE: I don't really like using them that much but it does kind of help. I just like taking traditional notes.

Interviewer: Is that the only way use see us as using Thinking Maps is just as notes?

WE: Um hum.

Interviewer: What have some of your experiences been with using Thinking Maps? Good? Bad?

BK: Good.

Interviewer: Can you tell me about something that you have used Thinking Maps for in math that is good?

BK: Like when you do the scientific notation, linear equations problems, where they have the Thinking Maps in them, where it breaks it down for you.

Interviewer: So like using the brace map to break it down?

BK: Yeah.

WE: Yeah, same thing with the brace map.

Interviewer: So do you like using the brace map to break down problems?

WE: Yeah.

BK: Yeah.

Interviewer: What about the flow map? Do you like the flow map? It's the one for doing sequencing.

BK: I don't think we've ever used it before.

Interviewer: We used it in the steps for solving multi-step equations?

WE: Yeah.

Interviewer: So what about the flow map? Do you like it?

BK: Yeah. It does the same thing like the brace map. It breaks it down easier for use to understand. Instead of us being confused about it.

Interviewer: What about a negative experience using Thinking Maps? Have you had a negative experience?

BK: I don't think so.

Interviewer: No?

WE: No.

Interviewer: Ok. That's good. What about in your opinion what is purpose of Thinking Maps in math?

BK: For us to understand the notes better. Like we….when we have a problem to do and we look at the brace maps and the flow maps and all that it like helps us work it out better and understand it better than us still be confused.

Interviewer: Ok.

WE: Um…

Interviewer: Just agree with that?

WE: Yeah.

Interviewer: How do you feel about using Thinking Maps in math?

BK: They help me out a lot better.

WE: Kind of in the middle. I like it but at the same time I hate it.

BK: Sometimes they are confusing to me. When we haven't used them.

WE: Yeah, we don't really use them that much.

Interviewer: Is it the map itself, the type of map that is confusing, like whether it is a bridge map or a brace map, that kind of thing? Or is it the stuff that you put in map that is confusing?

BK: The stuff you put in the map is confusing.

WE: Yeah the stuff you put in it.

Interviewer: Ok. What about when you hear your teacher say you are going to make a Thinking Map in math, what's your reaction?

BK: It's like…because we do one every nine weeks it feels like… it's like, I like it kind of.

WE: I'm like eww no. I really don't like them that much. I'm just not a big fan of them.

Interviewer: I know that in here because we do everything on the iPads we create our maps electronically so to speak, but it is really just like we would on paper and pencil because you are given a template you are just filling in the information in. If you could create them electronically where it created on all the bubbles and squares and everything for your and us just typed in the information, do you think you would like that better than the way we create the map now?

WE: Yes.

BK: Yeah.

Interviewer: Why?

WE: Because you don't have to draw all those bubbles and squares and you're afraid that they're going to be too big or too small.

BK: And like if you run out of space on paper you have to restart and everything, but electronically you don't really have to start over that bad like throw away paper or anything.

WE: Like in other words you don't have to erase it.

BK: Yeah.

Interviewer: That's all my questions. Do you have any questions or comments that you want to make about Thinking Maps?

WE: No.

Negative feeling toward Thinking Maps

Positive feeling toward Thinking Maps

Perception toward electronic Thinking Maps

Appendix H

Codebook

Code	Information
Negative feeling toward Thinking Maps®	Students' responses dealing with dislikes toward Thinking Maps® or the use of Thinking Maps®
Indicators:	I don't like, I hate it
Rule(s):	Any word or phrases that could identify characteristics that interviewees dislike Thinking Maps®
Positive feeling toward Thinking Maps®	Students' responses dealing with likes toward Thinking Maps® or the use of Thinking Maps®
Indicators:	I like, It's easier
Rule(s):	Any word or phrases that could identify characteristics that interviewees likes Thinking Maps®
Use/purpose of Thinking Maps®	Students' responses dealing with the use or purpose of Thinking Maps®
Indicators:	Taking notes, breaking down problems
Rule(s):	Any word or phrases that could identify characteristics that interviewees use of Thinking Maps® or perceived purpose of Thinking Maps®
Specific Map	Students' responses dealing with specific Thinking Maps® used in math the support student learning.
Indicators:	Circle map, bubble map, double bubble map, flow map, multi-flow map, brace map, bridge map, tree map
Rules(s):	Any word or phrases that could identify a specific map that students use to support student learning.
Perception toward electronic Thinking Maps	Students' responses dealing with their perception toward using the Thinking Maps® electronic platform.
Indicators:	It would be easier, I would not like, You don't have to
Rule(s):	Any word or phrase that could identify students' perception toward the electronic platform.

Appendix I

Interview 1 All

Question1: Can you tell me about using Thinking Maps in the math classroom?

AH: Like what do you mean?

Interviewer: Ok so like how and when have you used Thinking Maps?

BH: Say about seventh, sixth grade.

Interviewer: Do you like using Thinking Maps in the math classroom?

AH: Yeah. It's easier to understand. It's easier writing notes in Thinking Maps.

BP: They are better than regular note taking because you don't have to really write as much especially with the technology. I like that but it's still notes, so….

CB: I hate taking notes in math with thinking maps.

Interviewer: Why?

CB: I don't know. It's just a lot harder because math is like, it's more of like problems and like word problems.

Interviewer: Ok. Do you feel a connection between the maps and doing the problems?

CB: Yes.

BK: To me they are like easier to do than writing all these notes down because it like breaks it up.

WE: I don't really like using them that much but it does kind of help. I just like taking traditional notes.

Interviewer: Is that the only way use see us as using Thinking Maps is just as notes?

WE: Um hum.

Question 2: Experiences with Thinking Maps

Interviewer: So have you had good experiences using the Thinking Maps?

AH: Yeah.

Interviewer: Has there ever been a time that you had a bad experience using Thinking Maps in math?

AH: Oh no, not in math, not in math. Coach Ballew's I have.

BH: I just got problems with certain maps.

AH: Drawing

Interviewer: Which maps do you have a hard time with in math?

AH: The double bubble.

Interviewer: The double bubble?

AH: I don't like drawing it.

Interviewer: Just the mere fact of drawing it or is it putting the information in it?

AH: Yeah its drawing it.

Interviewer: Ok, so it's just a matter of drawing it that's the problem?

AH: Um Hum.

BH: Sequences. Sometimes sequences because we like rarely do it in here. That's the one that I struggle with.

AH: BH we use that one all the time, child.

BH: No we use….

AH: We use sequencing.

BH: No we use bubble. We use sequence, um no wonder I do bad with stuff. That's the one I struggle with.

Interviewer: What about what have been some of your experiences been with using Thinking Maps in math? Have you had good experiences?

CB: Yes.

BP: Yes.

Interviewer: Ok tell me about a time or a map or something that has been good for math.

CB: Taking the notes for slope and stuff.

BP: Doing the double bubbles, no the circle maps for the volumes and formulas and stuff.

Interviewer: Ok, have you had a bad experience with using Thinking Maps in math.

CB: No.

BP: No.

Interviewer: What have some of your experiences been with using Thinking Maps? Good? Bad?

BK: Good.

Interviewer: Can you tell me about something that you have used Thinking Maps for in math that is good?

BK: Like when you do the scientific notation, linear equations problems, where they have the Thinking Maps in them, where it breaks it down for you.

Interviewer: So like using the brace map to break it down?

BK: Yeah.

WE: Yeah, same thing with the brace map.

Interviewer: So do you like using the brace map to break down problems?

WE: Yeah.

BK: Yeah.

Interviewer: What about the flow map? Do you like the flow map? It's the one for doing sequencing.

BK: I don't think we've ever used it before.

Interviewer: We used it in the steps for solving multi-step equations?

WE: Yeah.

Interviewer: So what about the flow map? Do you like it?

BK: Yeah. It does the same thing like the brace map. It breaks it down easier for use to understand. Instead of us being confused about it.

Interviewer: What about a negative experience using Thinking Maps? Have you had a negative experience?

BK: I don't think so.

Interviewer: No?

WE: No.

Question 3: What is the purpose of Thinking Maps?

Interviewer: In your opinion, what is the purpose of Thinking Maps in math?

AH: For taking notes.

BH: To like divide certain ideas that you have.

AH: Um hum.

BH: So you can like see it better and like understand it better.

Interviewer: What about…in your opinion was is the purpose of Thinking Maps in math?

CB: To help you understand like the way that the problems are supposed to be.

BP: Making it easier to take notes.

Interviewer: Making it easier to take notes?

BP: Yes

Interviewer: Ok. That's good. What about in your opinion what is purpose of Thinking Maps in math?

BK: For us to understand the notes better. Like we….when we have a problem to do and we look at the brace maps and the flow maps and all that it like helps us work it out better and understand it better than us still be confused.

Interviewer: Ok.

WE: Um…

Interviewer: Just agree with that?

WE: Yeah.

Question 4: How do you feel about using Thinking Maps?

Interview: How do you feel about using Thinking Maps?

BH: I like them.

AH: I like them. I like them more than taking notes.

Interviewer: How do you feel about using Thinking Maps? Do you like using Thinking Maps? Do you hate using Thinking Maps? How do you feel about them?

CB: Sometimes I do but then sometimes I don't. Because some times its pointless and I don't understand it and sometimes I do.

BP: I like it because it's fun. Something different than just the usual taking notes.

Interviewer: Do you feel like, because you said sometimes its pointless, do you feel like if it was done in a reverse order like maybe you were presented with a problem and then a map that it would make more sense than instead of here's the map and here's a problem, use the map to do the problem?

CB: Yes.

Interviewer: How do you feel about using Thinking Maps in math?

BK: They help me out a lot better.

WE: Kind of in the middle. I like it but at the same time I hate it.

BK: Sometimes they are confusing to me. When we haven't used them.

WE: Yeah, we don't really use them that much.

Interviewer: Is it the map itself, the type of map that is confusing, like whether it is a bridge map or a brace map, that kind of thing? Or is it the stuff that you put in map that is confusing?

BK: The stuff you put in the map is confusing.

WE: Yeah the stuff you put in it.

Question 5: Reaction to teacher mentioning Thinking Maps

Interviewer: So when you hear me say we're going to making a Thinking Map, what's your first reaction?

BH: I mean nothing really. Just get it done.

AH: Get a piece of paper out. My first reaction is to get a piece of paper out. It's easier. I like using Thinking Maps more.

Interviewer: When you hear your teacher say you are going to do a Thinking Map, what is your reaction?

CB: I don't like it.

BP: Great.

Interviewer: Great as in a sarcastic way?

BP: Yeah.

Interviewer: Ok. What about when you hear your teacher say you are going to make a Thinking Map in math, what's your reaction?

BK: It's like…because we do one every nine weeks it feels like… it's like, I like it kind of.

WE: I'm like eww no. I really don't like them that much. I'm just not a big fan of them.

Question 6: Perception toward Electronic Thinking Maps

Interviewer: Ok. If you could do them on a computer, I know we do them on the iPad and the template is still that, but it is still like doing them on paper. If you could do it on the computer were it would make the bubble, fix them and everything for you, would you rather do the computer?

AH: Yeah.

BH: I wouldn't because I would like have to get used to it because I am used to drawing it on the iPads and on computers you have to resize the bubbles and stuff like that.

Interviewer: But if it automatically sized it for you, would you like it?

AH: Yeah. It would be easier because you wouldn't have to get confused with drawing it.

Interviewer: What about if you could…I know we use the iPads and we do them electronically on the iPads it's still just a template and it's just like doing it on paper and pencil, but if you had a computer program that you could use to make the Thinking Maps where it actually created the bubbles for you, do you think you would like that better than just the pencil/paper kind of way of making them?

CB: Yeah. Because I'm like OCD, so I have to make sure my circles are right and everything.

Interviewer: So you think you would as well BP?

BP: Yeah.

Interviewer: I know that in here because we do everything on the iPads we create our maps electronically so to speak, but it is really just like we would on paper and pencil because you are given a template you are just filling in the information in. If you could create them electronically where it created on all the bubbles and squares and everything for your and us just typed in the information, do you think you would like that better than the way we create the map now?

WE: Yes.

BK: Yeah.

Interviewer: Why?

WE: Because you don't have to draw all those bubbles and squares and you're afraid that they're going to be too big or too small.

BK: And like if you run out of space on paper you have to restart and everything, but electronically you don't really have to start over that bad like throw away paper or anything.

WE: Like in other words you don't have to erase it.

BK: Yeah.

Negative feeling toward Thinking Maps

Positive feeling toward Thinking Maps

Use/purpose of Thinking Maps

Specific maps that support learning math

Perception toward electronic Thinking Maps

Appendix J

Observation 3

Fieldnotes for Observations of Students Using the Thinking Maps electronic platform

Research Question: What is students' perception of Thinking Maps® in the math classroom? (These observations focus specifically on students' perception of using the electronic Thinking Maps® platform the generate maps)

Date: 3.12.15
Class period: 3rd
Type(s) of map created: Circle
Who determined the type of map and the information to be recorded on the map?
Teacher determined map, students determined content.

Descriptive	Reflective
Student Reactions: Excited, Loved the program, Some responses like "this is cool", "can we use this again"	Students found the program easy to use. Repeatedly stated that they liked that the shapes automatically resized to fit the amount of text.
Student Difficulties: not able to add text to frame of reference.	Glitch in the program? Design?
Student Successes: Able to build map, change color of shape and text. Able to use all features. Students felt the program was easy to use. Needed very little direction/support from teacher.	Students loved the font and color options. Students did not use color with purpose.
No. of students not able to complete the Thinking Map in the given time period: 2/20	Possible Reasons: Students used laptops to create maps. Two laptops dropped the wifi so students were not able to complete the map.

* students were able to save and share their created map.
* very little frustration with using the program.
* high student engagement
* very little off task behavior while using the TMLC

Appendix K

Survey Results for Map Generation(Questions 3 – 7)

Survey question	<50%	50%	>50%
What percent of the time are Thinking Maps® generated by the teacher in your math classroom?	17	22	18
What percent of the time are Thinking Maps® generated in small groups in your math classroom?	34	12	11
What percent of the time are Thinking Maps® generated individually in your math classroom?	33	9	15
What percent of the time do you create Thinking Maps® in your math classroom without being prompted by your teacher?	45	5	7
What percent of the time do you create Thinking Maps® using the electronic platform?	31	11	15

The data is the number of student responses for each category.

Survey Results for Student Perception Questions(Questions8 – 19)

Survey question	Strongly Disagree/ Disagree	Neutral	Strongly Agree/ Agree
How do you agree with the following statement: Thinking Maps® are beneficial for taking notes in the math classroom.	1	18	38
How do you agree with the following statement: Thinking Maps® are beneficial for solving problems in the math classroom.	11	15	31
How do you agree with the following statement: Thinking Maps® are beneficial for answering critical thinking questions in the math classroom.	5	15	37
How do you agree with the following statement: Thinking Maps® are beneficial for writing explanations in the math classroom.	2	21	33
How do you agree with the following statement: The Circle Map is useful in the math classroom.	1	20	36
How do you agree with the following statement: The Bubble Map is useful in the math classroom.	4	16	37
How do you agree with the following statement: The Double Bubble Map is useful in the math classroom.	7	22	28
How do you agree with the following statement: The Tree Map is useful in the math classroom.	4	16	36
How do you agree with the following statement: The Flow Map is useful in the math classroom.	7	19	30
How do you agree with the following statement: The Brace Map is useful in the math classroom.	10	15	32
How do you agree with the following statement: The MultiFlow Map is useful in the math classroom.	15	20	22
How do you agree with the following statement: The Bridge Map is useful in the math classroom.	9	19	28

The data is the number of student responses for each category.