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Investigating Student Learning and Perceptions Through Concept Journaling: An Exploratory Case Study in Coordinate Algebra

Amber Steele

ACCEPTANCE

This dissertation, INVESTIGATING STUDENT LEARNING AND PERCEPTIONS THROUGH CONCEPT JOURNALING: AN EXPLORATORY CASE STUDY IN COORDINATE ALGEBRA, by, AMBER E. STEELE was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chairperson, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

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INVESTIGATING STUDENT LEARNING AND PERCEPTIONS THROUGH CONCEPT JOURNALING: AN EXPLORATORY CASE STUDY IN COORDINATE ALGEBRA

by

AMBER STEELE

Under the Direction of Dr. Iman Chahine

ABSTRACT

In order for students to comprehend mathematics, they must be able to think and apply learned knowledge to inform skill acquisition (Schoenfeld, 2013). Written communication is a skill that enables students to prepare to learn mathematics and express thoughts. Using qualitative case study methodology within symbolic interactionism framework, this study examined the effect of concept journaling on the learning of seven students in one high school Coordinate Algebra classroom. The study further explored how these students perceived concept journaling as a tool for learning mathematics. Concept journaling is defined as a type of writing activity using prompts that incorporate graphs, charts, real-world situations, mathematical

formulas, diagrams, images, symbolic text, or other appropriate resources for the student to reflect, communicate, and express mathematical ideas through writing.

The students were interviewed at the beginning and end of the research. After a lesson was taught a concept journaling activity was assigned and the students were observed while engaged in a writing activity. Data was triangulated and collected using four techniques: interviews, observations, concept journals, and researcher/teacher's journal. Data analysis focused on comparing and contrasting themes that emerged through the detailed examination of the data. The following are emerging themes regarding student learning: through concept journaling (1) students learned by building associations of ideas utilizing their prior knowledge and experiences, (2) created a space for negotiating meaningful connections using multiple resources, and (3) provided opportunities for constructing meaning in context via peer communications and exchanges of personal views and ideas. The following are emerging themes regarding student perceptions: concept journaling was (4) seen as a meaningful experience to further their understanding of mathematics using real-world applications, (5) viewed by students as a medium to develop an awareness of the self while immersed in meaning making contexts, and (6) students expressed a sense of connection to mathematics through the use of concept journaling writing activities. Moreover, the findings highlighted a need for more focus on journaling in mathematics, longitudinal studies on writing in mathematics, and the students' voices appearing in future literature.

INDEX WORDS: mathematics, journal, qualitative, real-world application, writing, student learning, student perceptions, student voice, prior knowledge, experiences, multiple resources, peer communication, social connectedness, connection to mathematics, construct meaning, language of mathematics

INVESTIGATING STUDENT LEARNING AND PERCEPTIONS THROUGH CONCEPT JOURNALING: AN EXPLORATORY CASE STUDY IN COORDINATE ALGEBRA

by

AMBER STEELE

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DEDICATION

To Momma and Daddy, you have constantly supported me with love and encouragement throughout my continued education.

I will forever be grateful.

I love you.

There is a world out there to see.

To my husband, Adam, you have been my foundation in the completion of this degree and dissertation. You reminded me to remain positive throughout the past four long years. Thank you for believing in me – I could not have achieved this dream without you by my side.

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Introduction to the Problem

Over the past ten years, as a mathematics educator, I have witnessed first-hand many students hesitate, regardless of grade level and/or overall ability, to work through mathematics problems that are open-ended and require a greater level of thinking and problem-solving then simply equations (skill based problems that lack content). From my experiences these types of routine mathematical problems of drill and practice are what the students have come to expect in the mathematics classroom. These routine mathematical problems are becoming more obsolete based on the current trends of the national and state educational standards (Schoenfeld, 2013).

I have noticed mathematics and writing are two subjects that many students struggle with during their high school years. Yet, mathematics and writing involve critical skills that students must continue to master as they move through their academic course work and into the real-world. I have observed many high school students go through the motions and do the bare minimum to simply move from one mathematics and/or writing course to the next in order to graduate high school. Winn (2004) suggests that many of these students' struggles are because they have not made connections with the real-world or applied what has been taught in order to learn. In order to motivate student learning, Urquhart (2009) believes that teaching mathematics with the incorporation of writing is a way for students to make real connections between inside and outside of the classroom. With the incorporation of mathematics and real-world writing, the overall desire is that students are able to connect their mathematical learning to the real-world. And through this process, students will hopefully become more proficient at both real-world skills because concept journals incorporate mathematics and writing.

Purpose Statement and Research Questions

The purpose of this study was to examine how writing using concept journaling influences student learning in a high school Coordinate Algebra mathematics classroom and how students perceived concept journaling as a tool for learning. Concept journaling is a term that was developed by the researcher after the completion of a Specialist of Education thesis, *The Effects of Journaling in the Mathematics Classroom* (Thornton-Steele, 2007). Concept journaling is defined as a type of writing activity using prompts that incorporate graphs, charts, real-world situations, mathematical formulas, diagrams, images, symbolic text, or other appropriate resources for the student to reflect, communicate, and express mathematical ideas through writing. In addition, there are multiple layers to concept journaling in the mathematics classroom: real-world application, students' written response, students' flexibility to utilize resources, and teacher's response to the process of writing. An example of a concept journal writing activity is detailed here: You plan to sell your car to a friend for $4,250. Your friend cannot pay the full amount at once; therefore, you have agreed to a non-interest payment plan. Write a contract between you and your friend (include the down payment, monthly payment plan, etc.). Graph the function and create a table for the payment information. (See Appendix A for concept journal writing activities.) The process of completing a writing activity utilizing concept journaling starts with a lesson that is presented to the class through a discussion of mathematical vocabulary, application problems, and making connections to the real-world. The lesson presented establishes an understanding of the concept journal topic. The concept journal activity provides an opportunity for students to respond to an open-ended real-world application problem through writing. Concept journaling as a writing tool for learning mathematics encompasses more than basic writing skills of creating sentences and paragraphs. For example,

while completing a concept journal writing activity, participants will have the opportunity to use words, symbols, shapes, etc. to create graphs, tables, and drawings that will allow students to further understand mathematical concepts and procedures. As the students complete the writing activity, the teacher will provide feedback to the students. For the purpose of this study, writing was considered any symbolic composition created while working through the open-ended application problem of the concept journal writing activity. Using qualitative case study methodology located within symbolic interactionism framework, this study examined the learning of seven high school students in a Coordinate Algebra mathematics class. Specifically, the study soughed to answer the following questions:

1. How does the use of concept journaling, as a writing activity, influence student learning in a high school Coordinate Algebra mathematics classroom?
2. In what ways do students perceive concept journaling as a tool for learning mathematics?

Rationale and Significance of Study

As the expectations and standards of education continue to rise, it is of utmost importance that students are able to perform to the best of their ability. Schafersman (1991) implies, "it is vital to spend time, not learning more information, but, learning methods to acquire, understand, and evaluate this information and the great amount of new information that is not known" (p. 2). When students simply know how to do mathematics, but have trouble connecting the subject to outside of the academic classroom, we, as educators, have "failed to teach students how to think effectively about this subject matter, that is, how to properly understand and evaluate it" (p. 1).

When students begin to realize that they are able to participate in written communication, dialog, inquiry, and debate inside the classroom they become more engaged (Thornton-Steele, 2007). Through this participation, the students are able to make meaningful contributions to their

own learning and the learning of their peers. Vavilis and Vavilis (2004) stated, “one such mistaken assumption [that students make] is that subject matter can be learned only by listening carefully and modeling teacher processes” (p. 286). For students to comprehend topics, they must be able to think and to apply learned skills. Written communication is a skill that enables students to express thoughts and that helps students in the process of learning mathematics. As Jamison (2000) explores the importance of written communication in conjunction with mathematics, he finds that the mathematical formulas and application problems, which are linked to the real-world, should be the vehicles for expression of deeper mathematical thought (p. 45). In a similar vein, Consiglio (2003) argues that in-class writing is one way to foster mathematical understanding. For the purpose of this study, concept journals were used to understand how the writing activities influenced student learning in a high school Coordinate Algebra classroom and how students perceived concept journaling as a tool for learning mathematics. Powell (1997) states, "Writing not only captures mathematical thinking but also facilitates learning in powerful ways" (p. 3). Concept journaling is a writing activity that can bridge real-world application and writing for overall deeper mathematical understanding. The rationale behind the study was to gain an in-depth understanding of the role of writing in student learning in mathematics and to document the perceptions of the students in regard to using concept journaling as a tool for learning mathematics.

Limitations

The study has a number of potential limitations:

1. The concentration of my study was on secondary students; therefore, the same study performed at a lower or higher level of education possibly may not have the same results.
2. The research was limited to a course of Coordinate Algebra students.

3. Because of the school calendar, the duration of the research was 7-weeks, and this may affect the nature of the qualitative data collected.
4. I was the teacher of this Coordinate Algebra class; I gathered evidence for this research study. During the duration of this study, I was cautious against my subjectivity and strived to remain unbiased.

Theoretical Framework

A theoretical framework is the lens in which a research study is guided and an epistemology is the understanding of how an individual constructs knowledge (Crotty, 1998). This section provides a concise historical background and critique of symbolic interactionism. In addition, several studies are explored in Chapter 2 that employed a symbolic interactionism framework in the mathematics education field. In conclusion, an overview linking symbolic interactionism and constructionism is presented to promote concept journaling in the mathematics classroom.

Historical Background and Critique of Symbolic Interactionism

Research throughout the 1940s and 1950s launched symbolic interactionism into a direction which allowed a sociological "movement" that revolved around the forefathers who established the framework foundation. As research moved forward into the next two decades, 1960s and 1970s, the scholars that utilized the fundamental ideals of symbolic interactionism greatly declined (Stryker, 1987). Many scholars considered symbolic interactionism to be unscientific and lack vitality because the framework did not adequately incorporate "the social significances…of social structure, in particular of social class and power distributions within society" (Stryker, 1987, p. 85). The revitalization of symbolic interactionism began in the 1980s because of the "great variety of theoretical and empirical work that, in part of or in whole, self-

consciously symbolic interactionist in derivation or not really cognizant of the link, is tied to that framework" (p. 87). From the 1980s forward, scholars who situate their research around symbolic interactionism do not appear to be slowing down. Granted, there are still several critics of symbolic interactionism who state that the framework is too vague and does not take into account diverse social structures and hierarchy. Fine (1993) suggests that symbolic interactionists have made major research contributions through the empirical arenas of "social coordination theory, the sociology of emotions, social constructionism, self and identity theory, macro-interactionism, and policy-relevant research" (p. 61). Through these arenas, Fine (1993) claims that there will continue to be more intermarriage, more interchange, and more interaction as scholars continue to use symbolic interactionism as a framework (p. 81-2). Many researchers are able to employ this framework not only with the use of qualitative data analysis (observations, interviews, surveys/questionnaires, journals, etc.), but also (moving slowly into) quantitative data analysis. Regardless of the research approach, Fine (1993) suggests that the goal of symbolic interactionism is to continue to develop a practical approach to researching social life and the power of symbols and interactions.

Symbolic Interactionism

A theoretical perspective is “the philosophical stances informing the methodology and thus providing a context for the process and grounding it in logic and criteria” (Crotty, 1998, p. 3). Symbolic interactionism is a theoretical perspective that focuses on how individuals make overall meaning through interactions. Fine (1993) states, "George Herb Mead is the primary source of the perspective of symbolic interactionism was the writings and teachings of Herbert Blumer" (p. 63). In 1934, Mead wrote *Mind, Self, and Society* while he was affiliated with the University of Chicago. This book became the foundation of what is known as symbolic

interactionism. Inspired by Mead's work, Blumer (1969) outlines three premises of symbolic interactionism:

1. that human beings act toward things on the basis of the meanings that these things have for them;
2. that the meaning of such things is derived from, and arises out of, the social interaction that one has with one's fellows'; and
3. that these meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he [or she] encountered. (p. 2)

In essence, "from these philosophical roots, symbolic interactionism began with the premise that the individual and society are interdependent and inseparable - both are constituted through shared meaning" (Pascale, 2011, p. 78).

During the revitalization of symbolic interactionism, many scholars have furthered the foundational framework of symbolic interactionism in order to meet the demands of current research (Fine, 1993). There are several interpretations of the original premises of symbolic interactionism and how it centers on human experiences. Utilizing the work of Mead and Blumer, several other social researchers have further developed their own definition of symbolic interactionism. Using the foundations of Blumer, academic scholars Sandstrom, Martin, and Fine (2001) outlined the tenets of symbolic interactions as follows:

1. People are unique creatures because of their ability to use symbols
2. People become distinctively human through their interactions
3. People are conscious and self-reflexive beings who actively shape their own behavior
4. People are purposive creatures who act in and towards situations
5. Human society consists of people engaging in symbolic interactions
6. To understand people's social acts, we need to use methods that enable us to discern the meanings they attribute to these acts. (p. 218-9)

There are numerous interpretations of symbolic interactionism. For example, Crotty (1998) argues that symbolic interactionism "deals directly with issues such as language, communication, interrelationships and community...it is all about those basic social interactions whereby we enter into the perceptions, attitudes and values of a community" (p. 7-8). Although

there are various definitions of symbolic interactionism cited in the literature, however, all definitions are inspired by and are based on the foundational premises of Mead and Blumer's work. For instance, Seibold (2011) explains that through symbolic interactionism "someone's sense of meaning is interpreted through social interactions, and the communication and understanding of verbal and non-verbal sociocultural symbols" (p. 4). Essentially, symbolic interaction is the basis of three focal points: meaning, language, and thought (Griffin, 1997). Through these three focal points, a person is able to apply meaning to his/her own *self.* And as the interactionist, the researcher seeks answers of how people use symbols to classify, exchange meaning and understand how individuals negotiate social realities.

Rationale for Conceptual Framework

This study employed a symbolic interactionism framework that involved three major tenets; language, thought, and meaning. Symbolic interactionism is a good match for concept journaling because the process of coming to know and further understand mathematics is constantly developing through these three tenets. For example, in a mathematics classroom, a student will be further introduced to a mathematical topic through language, this language will cause thought, and therefore, the student will conclude with further meaning of the topic. With the use of concept journals as a tool for learning mathematics, the participants had the opportunity to explore language, thought, and meaning through writing in a Coordinate Algebra mathematics classroom. In this sense, mathematical knowledge was possibly evolving as the participants were able to create and explore mathematical language, thought, and meaning during the duration of the lesson, discussions throughout the class, and through concept journal writing activities (*Figure 1*).

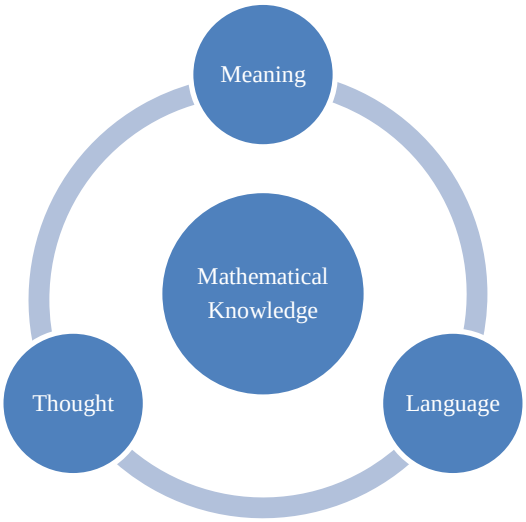


Figure 1. Developing Mathematical Knowledge through Symbolic Interactionism

As shown in Figure 1, using symbolic interactionism framework, mathematical knowledge is configured through three major tenets: language, thought, and meaning. The process of mathematical understanding, through symbolic interactionism, begins with language. The language of mathematics is diverse as it consists of words, symbols, equations, graphs, diagrams, charts, texts, etc. Language signifies the role of oral and written communication in understanding the different symbols that are located within mathematics. As Banker (2004) states, "Mathematics is a precise language full of abstract symbols and notation that have no meaning without careful consideration of their purpose" (p. 15). Mathematical language is a process that develops over time, often through multiple sources. As students learn mathematics, their understanding and use of the mathematical language becomes more fluent. As the participants were presented with a concept journal writing activity, they were required to produce a response that essentially connected their understanding of mathematics, symbols, and their social realities through written communication.

Meaning, the second tenet, refers to how a student interprets the mathematical symbols. A student's interpretation of the symbol is a direct reflection on his/her understanding of

mathematics. Through this understanding, each student could respond differently on the foundation of the mathematical symbol meaning for him or herself because of the various prior interactions and experiences that student has participated in throughout life. When students were presented with a concept journal writing activity, they were granted the opportunity to further explore mathematical meaning through prior experiences that linked their outside world to the inside of the classroom. Through the process of concept journaling, there is a possibility that the writing activity could influence student learning.

The third tenet is thought where greater sense of meaning comes through one's ability to reflect and think. As Crotty (1998) states, "There is no meaning with a mind. Meaning is not discovered, but constructed" (p. 9). As students reflect and think on the language and meanings of mathematics, they become more aware of the process of learning mathematics. In relation to concept journaling, the students were required to respond through written dialog to a writing activity. As the students responded, they were able to organize their thoughts before writing begins, as the written response was composed, and continued through completion of the concept journal writing activity.

Essentially, concept journaling is a tool for learning mathematics through writing. Writing, broadly defined as any symbolic composition created while working through the open-ended application problem of the concept journal writing activity, is the thread between language, meaning, and thought. Students were able to utilize writing as a cognitive tool in order to reflect on the meanings of mathematics as they translated mathematical language to meaning through symbols, words, graphs, text, and/or diagrams and vice-versa. The concept journal writing prompts were posed for open-ended responses. These open-ended writing topics allowed

the students the opportunity to reflect on their own personal experiences and social interactions as they utilized language to convey a written response.

Within a social context, language, meaning, and thought are constantly evolving. These three tenets of symbolic interactionism cannot be separate within a social context. And the same holds true of these tenets within a mathematics classroom. When the students were presented with a concept journal writing activity, the students were given the opportunity to translate mathematical language into meaning by utilizing thought and social tools of composition. In essence, concept journaling is a type activity that allowed the students to link their real-world knowledge and prior experiences with the mathematics classroom. Basically, while the students were responding to a concept journaling prompt they were solving problems utilizing various resources and through social interactions.

Through the use of the conceptual framework, I was able to further investigate the perceptions of the students and how they perceived concept journaling as a tool for learning mathematics. Prusak, Davis, Pennington, and Wilkinson (2014) suggest that "with students as the ultimate consumers of education, reason suggest that their perception and perceptions could yield valuable insight and information" (p. 8). In this particular study, students had the opportunity to express their thoughts regarding writing in mathematics, what the meaning of writing was, and how to utilize language while writing in the mathematics classroom.

Through symbolic interactionism, there is a link between the individual's overall knowledge growth and their social advancement. The classroom is seen as a social environment that gives the students and the teacher opportunities to interact activities (i.e. conversations, mathematical problems, writing assignments, real-world discussions). As the teacher and students interact, there is an opportunity for mathematical understanding to emerge and social

interactions between the students and teachers to perhaps further develop. Amidst social interactions that are in constant cultivation between the teacher, students, and mathematical content, individuals come to know their roles (the teacher facilitates the mathematical lesson and the students are present to learn) in the social setting (the classroom). Granted, the responsibility is on the teacher to be a facilitator of mathematics and become aware of prior knowledge and interest of students that will allow them to understand mathematics through meaning, language, and thought.

Epistemology of Constructionism

A key epistemology aligned with symbolic interactionism is constructionism. Crotty (1998) states that epistemology "guides the theoretical perspective" (p. 2) and "involves knowledge, therefore, and embodies a certain understanding of what is entailed in knowing, that is, *how we know what we know*" (p. 8). The epistemological view of writing in the mathematics classroom is grounded in constructionism where, "truth or meaning, comes into existence in and out of our engagement with the realities in our world…meaning is not discovered, but constructed" (Crotty, 1998, p. 8-9). In this epistemology, knowledge is a process that relies on social agreements that are created through human realities. Society is composed of human beings who are born, created, and live in a culture together that have already constructed meaning about objects and symbols (Seibold, 2011). Through this culture, we each experience different forms of truths and understanding about the world in which we live and participate. During this constant and continuous participation, we develop a sense of understanding that is embedded and constructed in social settings, discourses and practices that come together to form reality (Chapman, 2006). Essentially, a person's reality is a construction of ongoing interactions between the individual and society, culture, and knowledge which is based on meanings that are

developed in social contexts. Therefore, symbolic interactionism has a direct connection to constructionism because as individuals we are constantly (consciously or not) using symbols in order to interact with one another and construct meaning in social settings. Through these symbolic interactions, individuals continue to further construct meaning of social settings. Moving forward, the next section will link symbolic interactionism and constructionism to concept journaling.

Linking Symbolic Interactionism and Constructionism to Concept Journaling

In the stance of symbolic interactionism and constructionism (see Figure 2), "Humans learn what things mean as they interact with one another. In doing so they rely heavily on language and the communicative processes it facilitates" (Sandstorm, et al., 2001, p. 218) and that the "self arises out of communication" (p. 220). By linking symbolic interactionism and constructionism, this study aims to understand how students learn mathematics through oral and written discourses as they engage in a writing activity (i.e., concept journaling). Specifically, the four methods used to collect data (i.e., interviews, observations, concept journals, and researcher/teacher's journal) revolve around the conceptual framework of symbolic interactionism (language, meaning, and thought) that guided the interpretation of the findings. This framework guided what is noticed through language, meaning, and thought while utilizing concept journaling, as a writing activity, to possibly influence student learning. In addition, this framework helped understand how the students perceived concept journaling as a tool for learning mathematics as a way to understand language, create meaning, and compose their thoughts in order to further mathematical knowledge. Through the theoretical framework "symbolic interactionism seeks to uncover meanings and perceptions on the part of the people participating in the research" (Crotty, 1998, p. 7). With the verbal and non-verbal information

collected from the interviews, observations, concept journals and the researcher/teacher's journal, the study endeavored to gain an understanding of students' experiences with writing and their perceptions of learning acquired through concept journaling in a Coordinate Algebra classroom. These mathematical writing activities supported the idea that based on students' experiences, knowledge is socially constructed. Furthermore, how the students perceived writing to learn assisted in understanding how concept journaling is utilized as a tool for learning mathematics.

As it has been previously confirmed through symbolic interactionism, it is essential for meaning, language, and thought to unite in order for mathematical understanding to develop (Figure 1). As mathematical understanding is further developed, an individual must be able to utilize the language of mathematics in order to translate symbols into meaning through thoughts. Further elaborating on Figure 1, Figure 2 illustrates how constructionism links with symbolic interactionism: an individual's prior experiences, knowledge, and interactions will affect his/her overall learning. Constructionism is the process of constructing meaning, further coming to know and understand the world around us through interactions and prior experiences. This study incorporated writing inside the mathematics classroom to examine how students' prior experiences, knowledge, and social interactions connected with meaning, language, and thought as they further developed their learning.

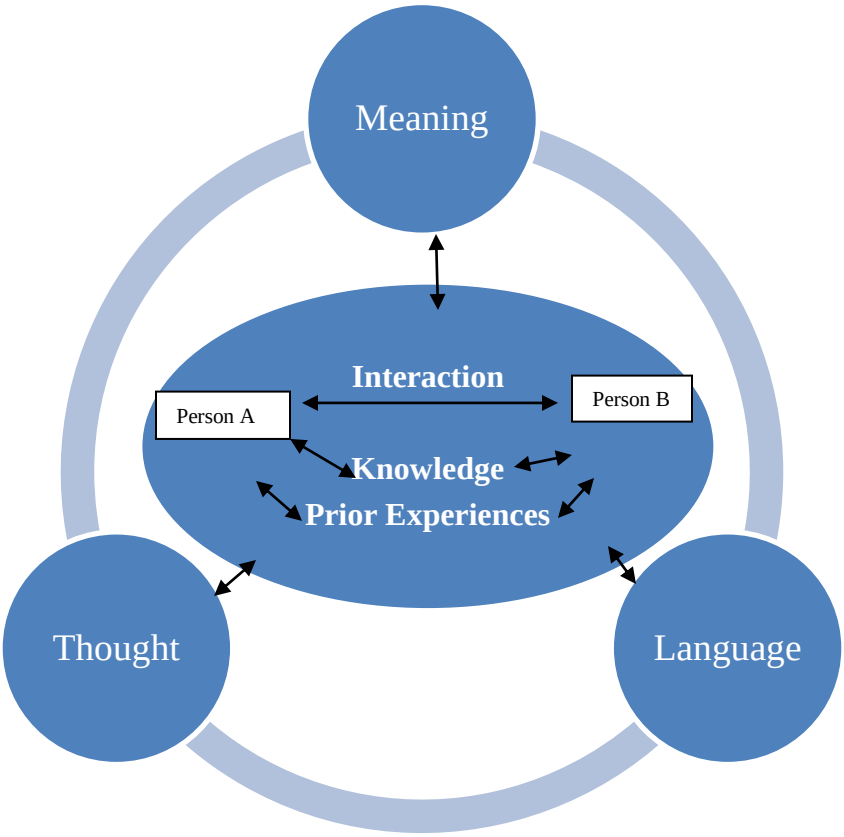


Figure 2. Linking Symbolic Interaction to Constructionism through Mathematical Knowledge and Concept Journaling.

As students were presented with a concept journal writing activity, they were essentially constructing their responses using language, meaning, and thoughts in conjunction with social interactions and prior knowledge in order to further gain knowledge and understanding of mathematics. In addition, the students were asked to reflect on how they perceive writing as a tool for learning mathematics through the concept journal writing activities. Therefore, this study will answer how writing through a concept journal influences students learning and how students perceived concept journaling as a tool for learning mathematics through the connections of symbolic interactionism and constructionism.

Organization of Dissertation

Chapter 1 provided a brief overview of the study's purpose, research questions, rationale, and significance, justification of the theoretical framework and epistemology, and the limitations of investigation of student learning and perceptions through concept journaling in a Coordinate Algebra mathematics class. Chapter 2 examines research studies that have employed symbolic interactionism as a lens to explore mathematics learning, gives an overview of writing, and reviews empirical research literature of journaling and writing in the mathematics classroom. Chapter 3 details the research methodology used in this study, including a description of the data collection techniques (i.e., interviews, observations, concept journals, and the researcher/teacher's journal) employed to investigate how concept journal writing activities influenced student learning in a high school Coordinate Algebra classroom and how students perceived concept journaling as a tool for learning mathematics. Chapter 4 provides methods of analysis, a detailed examination of the results and connections to the three tenets of symbolic interactionism (thought, meaning, and language) and constructionism in each emerging findings. In concluding this research study, Chapter 5 will connect the emerging themes to the literature, present implications for practice, offer recommendations for future research, and provide final words.

CHAPTER 2

Review of the Literature

To begin this literature review, empirical research studies (Schwarzkopf, 2003; Tatsis & Koleza, 2002; Walls, 2003) will be reviewed that have employed symbolic interactionism as a lens to explore mathematical learning and a detailed overview of writing in mathematics will be presented. A search criteria and methods will be discussed before the literature is presented to understand how and why the action of writing is directly linked to the mastery of learning. The overall purpose of this literature review is to synthesize and critique empirical studies that examine the use of journal writing strategies inside the mathematics classrooms taking into account the way mathematical knowledge is conceivably formed through meaning, language, and thought. Throughout the literature, there is a consistent finding that writing to learn contributes to positive academic growth for students (Banker, 2004; Baxter, Woodward, & Olson, 2005; Grbavac, Piggott, & Rougeux, 2003; Koirala, 2002; Kostos & Shin, 2010). This research will further the understanding that when students are given the opportunity to write, their learning advances. Even though there have been studies that investigated utilizing various writing strategies in the mathematics classroom using qualitative and quantitative approaches, very few studies focused on the influence of writing strategies on student learning from the students' point-of-view. Furthermore, none of the empirical research encompasses the multi-layers of representation (i.e., real-world application; students' written response; and students' flexibility to utilize resources; and teacher's response to the process of writing) that emerge through concept journaling in mathematics.

Research Employing Symbolic Interactionism in Mathematics

There are several research studies that employ a symbolic interactionism framework as a lens for furthering the understanding of mathematics education (Schwarzkopf, 2003; Tatsis & Koleza, 2002; Walls, 2003). These studies range from examining student learning at different grade levels to understanding the language of mathematical problem-solving and analyzing how students interact with word problems embedded in real-world contexts. In all of the scholarly literature on symbolic interactionism in a mathematics environment, the research studies focus on how the participants constructed knowledge through an interactive process. Concept journaling allows the student to further construct his/her knowledge as interactions take place between and among students, teacher, and resources.

Schwarzkopf (2003) outlined how to analyze symbolic interactions between students and the teacher while solving word problems within an elementary mathematics classroom. He suggested that there are two frames surrounding mathematical word problems: everyday real-world understanding and mathematical knowledge (p. 2). How an individual manipulates the space between a mathematical word problem and the real-world is when the two framings begin to collide. With the use of symbolic interactionism, Schwarzkopf illustrated how mathematical knowledge is categorized among symbols, references context (basic interpretation of the symbol), and mathematical concept (p. 2). Through these components learning becomes a circular process that allows the students to operate between mathematical and real-world knowledge.

Furthermore, Tatsis and Koleza (2002) were interested in understanding how students utilized language while working to solve a mathematical problem in pairs. The authors posed the following three questions: "Does the use of everyday or quasi-mathematical language affect the

common understanding of the participants? Were there any observable social and sociomathematical norms constituted in the interaction?; How is language used by the participants to reveal their roles in the interactions?" (p. 4). The authors argued that symbolic interactionism framework was useful since, "Language gives humans a means by which to negotiate meaning through symbols…human communication is made possible through the use of symbols (symbolic interaction)" (p. 2). The study sample consisted of ten pairs of undergraduate elementary education students (twenty total students) from the University of Ioannina (Ipiros, Greece), and each pair was asked to solve a Euclidean geometry problem as a group and to verbalize every thought that was made regarding the problem. Using discourse analysis, the researchers found that students used different strategies including everyday or quasi-mathematical language (p. 3) and/or mathematical justification (p. 4) to successfully solve the problem. In addition, the researchers observed that there were different 'roles' that each student portrayed in every pair: an initiator and interpreter (p. 6). Overall, the research concluded that students constructed shared meaning in the course of the interactions; students were stimulated based on social and sociomathematical norms and students played distinct roles (p.6).

In another study, Walls (2003) explored the everyday lives of children and their attitudes and experiences of mathematics. The overarching research questions were, "What does the mathematical world of the child look like, how do the interactions with that world contribute to the child's negotiation of meaning about that world, and what aspects of that world appear to enhance or inhibit the child's learning of mathematics?" (p. 3). To guide this research, a symbolic interactionism framework was utilized because it was able to portray the relationship between the child and the school environment. Ten students were randomly selected from a primary school in New Zealand at the beginning of their third year and were followed for a maximum of

three times per year until the end of their fifth year of school. In order to gather data that would adequately describe the children's' sociomathematical world, the research utilized biography as the primary methodology. In addition, the author collected field notes on the each children's physical settings, situations/events, informants, and archival materials. During the data analysis, there were four themes of the sociomathematical world that emerged: speed activities; customization of mathematical ability; understanding mathematical procedures; and comprehending correct versus incorrect for mathematical facts and procedures (p. 7). Students were able to utilize the language of mathematics, interpret meanings of symbols, and construct thoughts in order to further their mathematical knowledge. With the use of symbolic interactionism as a theoretical framework, "the research placed the child learner in the centre of the investigation, and employed methodological tools that provided a much-needed 'voice' for the child's lived experience of mathematical learning" (p. 7).

After further exploring symbolic interactionism, in particularly in mathematics education, it appears that people use fixed symbols in flexible and creative ways through interactions of the student(s), the teacher, and/or peer-to-peer. In addition, in the publications referenced here (Schwarzkopf, 2003; Tatsis & Koleza, 2002; Walls, 2003), an overall pattern was noticed in all of the findings; the data analysis unveiled how meaning, language, and thought are used as tools by the participants in order to interpret and communicate within a social setting. Furthermore, in terms of a mathematics classroom, the empirical research that has employed symbolic interactionism in mathematics suggests meaning, language, and thought are critical to the overall development of mathematical knowledge. This literature on symbolic interactionism argued that the focus is on the students and their experiences of using language, meaning, and thought in connection with social interactions. These interactions, supplemented by prior experiences, help

students gain further understanding of mathematics and extend their knowledge to the real-world.

Understanding Writing as Learning

The definitions and forms of writing are vast across many disciplines and pedagogical practices. Therefore, several definitions have been explored to further understand learning through concept journaling. The conceptual framework suggests that mathematical knowledge is conceivably formed through meaning, language, and thought. Writing is a fundamental tool that allows an individual to employ language, meaning, and thought as a message is composed. The definition of writing proposed by Prior (2006) fits the implementation of writing activities through concept journaling as he states:

> Writing involves dialogic processes of inventions. Text, as artifacts-in-activity, and the inscription of linguistic signs in some medium are parts of streams of mediated, distributed, and multimodal activity. Even a lone writer is using an array of socio-historically provided resources (languages, genres, knowledge, motives, technologies of inscriptions and distribution) that extend beyond the moment of transcription and that cross modes and media (reading, writing, talk, visual representation, material objectification). (p. 58)

Utilizing Prior's definition of writing, it accepts that a writer will use an array of socio-constructed language techniques to portray a message. Through this message the writer must come to an understanding of what the language means. Therefore, a writer must compose his/her thoughts before portraying the message.

Furthermore, Newell (2006) suggests that "writing is a psychological event that occurs within a social setting and/or social events" (p. 237) and simply stated by Fisher and Frey (2012), "Writing is a form of thinking" (p. 58). Each of the definitions of writing provided gives an insight into concept journaling writing activities. Prior (2006) adopts the multimodal aspect of writing through different forms and aspects of writing. Whereas Newell (2006) gives credit that

writing occurs through social interactions and Fisher and Frey (2012) argue that in order to write an individual must think. When students are given the opportunity to apply past and present knowledge through social interaction with others and self-selected resources, the process of learning begins to take a different more personal form, which in turn leads to acquiring higher order thinking. As Freitag (1997) suggests, "writing may require the student to have a greater understanding of the content" (p. 19). Essentially, an individual must be able to utilize language, apply meaning, and compose thoughts in order to be able to effectively write.

Learning truly begins when students are allowed opportunities to gain knowledge in meaningful ways. Emig (1997) advocates that learning encompasses "the classical attributes of reinforcement and feedback…connective and selective…makes use of propositions, hypotheses, and other elegant summarizers...it is active, engaged, personal" (p. 124). Learning how to write is generally a very difficult skill to master because there are "no recipes: each rhetorical situation is unique and thus requires the writer, catalyzed and guided by a strong sense of purpose, to reanalyze and reinvent solutions" (Ede & Lunsford, 1984, p. 164). In addition, Emig (1997) has found through research that "writing involves the fullest possible functioning of the brain, which entails the active participation in the process of both the left and the right hemispheres. Writing is markedly 'bispheral'" (p. 125). When one begins to write, regardless of the audience, rhetoric, or social environment, the written expressions take on meaning that is unique and requires the writer to understand many aspects of different forms of language, words, and symbols, all the while the brain is engaging the left and right side.

In addition to incorporating research-based practices in facilitating student learning and understanding students as individuals, the objective of this study was to further teach mathematics while incorporating writing as the students learn. It has long been argued that the

way mathematics has been taught in traditional settings does not foster the skills that help move a student into the next phase of life. In Schafersman's (1991) book *Introduction to Critical-Thinking*, he argues that in many classrooms students are often not challenged enough to increase their critical-thinking dispositions or problem-solving skills. Particularly prevalent in the American culture, engaging in different types of rhetoric is a crucial life skill. The American culture highly appreciates literacy and educational structure. In order to help students further develop these crucial life skills, reading and writing should be reinforced in all academic levels and coursework to foster learning. With the use of the tenets of symbolic interactionism and constructionism, this study will further allow an investigation of writing in mathematics. Specifically addressing how student learning is influenced through the concept journal writing activities and how students perceive these writing activities as a tool for learning mathematics.

NCTM Through Today's Mathematics Classrooms Standards

The National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000) document outlines principles and standards that are essential and should be incorporated in educational mathematical settings with the intent that students become successful mathematicians. NCTM (2000) states that the principles, "reflect basic perspectives on which educators should base decisions that affect school mathematics" (p. 7) and the standards, "describe an ambitious and comprehensive set of goals for mathematics" (p. 8). According to NCTM, teaching mathematics requires planning to develop strategies, lessons, and activities that increase students' ability to gain and implement learned skills through assessments and real-life situations. Countryman (1993) suggests that educators "create situations where students can be active, creative, and responsive to the physical world" (p. 51). Therefore, to meet the emphasis and demand of the nation and states' principles and standards, mathematics

teachers have turned to writing (Countryman, 1993). Countryman's notion is further supported by NCTM (2000) who suggests, “Writing in mathematics can also help students consolidate their thinking because it requires them to reflect on their work and clarify their thoughts about the ideas” (p. 61). This particular research study aims to support the notion that writing in mathematics influences student learning of mathematical knowledge. In addition, this research will provide the students' perceptions of writing as a tool for learning mathematics.

Understanding Learning Through Writing in Mathematics

Angelo (1993) contends that when students make connections between their prior knowledge and what they are currently learning, the more they will retain the new information into long-term memory. Therefore, it will be easier for the students to access that information when needed later. Writing is one way to foster student learning in mathematics. Understanding how writing influences a learner's ability to apply knowledge and foster a comprehension of the subject material has long been documented in the literature. As Mayher, Lester, and Pradl (1983) elegantly state:

> Writing's capacity to place the learner at the center of her own learning can and should make writing an important facilitator of learning anything that involves language. Writing that involves language choice requires each writer to find her own words to express whatever is being learned. Such a process may initially serve to reveal more gaps than mastery of a particular subject, but even that can be an immense diagnostic value for the teacher and learner alike. And as the process is repeated, real and lasting mastery of the subject and its technical vocabulary is achieved. (p. 79)

Historically, the field of mathematics is seen as a universal language with only correct answers or incorrect answers. Jamison (2000) states, that “many people see mathematics only as a collection of arcane rules for manipulating bizarre symbols – something far removed from speech and writing” (p. 45). In my teaching experiences, mathematics appears to many students to be a very black and white subject with no gray allowed. I believe that when students are given

the opportunity to write in the mathematics class, it ultimately is allowing them to explore the "gray" area(s) within mathematics. Using writing in mathematics will allow the students opportunities to be able to reflect on their understanding and recognize the various possibilities of their ideas in a meaningful way.

Even with the research findings in the early 1980s connecting writing to learning and the mastery of particular subjects, the implementation of writing did not seem relevant inside the American mathematics classroom until the NCTM publication of the 1989 *Principles and Standards for School Mathematics*. It is because of the NCTM (1989) research reports that writing in mathematics began to flourish in learning environments. The findings of studies that incorporated writing with mathematics further supported the findings of general language art writing education. Simply stated, regardless of the academic subject being taught when writing is incorporated, students learned more.

Search Criteria and Methods

My literature search focused on empirical research in primary, middle, secondary and post-secondary writing exclusively related to journaling in mathematics classrooms. I specifically focused on the empirical research starting from 2002 that met my search criteria because I am attempting to further the most current research regarding writing in mathematics. To identify solely empirical studies from 2002 onward that focused on journaling in mathematics, I conducted a search in the relevant online databases subscribed to by the Georgia State University Library, including but not limited to ERIC and JSTOR. My search criteria included keyword terms such as math/mathematics/mathematical, journal/journaling, writing, and written communication. My overall goal was to locate studies that portrayed the current empirical research in writing in mathematics. From these inquires five studies were found

adequate to meet my search criteria (Banker, 2004; Baxter et al., 2005; Grbavac et al., 2003; Koirala, 2002; Kostos & Shin, 2010). In addition, publications are included that were recommended by advisors and colleagues that did not appear in my searches but met my search criteria. For example, several primary scholars (Countryman, 1992, 1993; Dougherty, 2006; Powell, 1997; Urquhart; 2009) on writing in mathematics have utilized prior teaching experiences to author several theoretical writings.

Empirical Studies on Student Learning Through Writing in Mathematics

As the mathematics educational standards and principles begin a movement away from skill-and-drill and rote memorization, it is apparent that educators need to focus on teaching "real math" that engages students in making sense of mathematics through classification and inference (O'Brien & Moss, 2004). Battista (1999) believes that in many classrooms, mathematics is presented in a teacher-centered, lecture form of instruction. In several teaching scenarios, the process teachers seemingly go through on an everyday basis to teach mathematics to students is repetitive – the teacher lectures, the students takes notes, the teacher assigns meaningless problems – there is no connection between the students, teacher, and subject matter to real-world experiences. Students are not able to apply what is learned in mathematics to other content areas nor are they able to apply what is learned to the next topic taught in mathematics (Schafersman, 1991).

As a dynamic environment, the classroom should continue to stay up-to-date. Teachers should be encouraged to create applicable lessons, lessons that are hands-on, thought provoking, stress critical-thinking dispositions, and problem-solving strategies (Borko & Elliott, 1999). Battista (1999) envisions that in a successful math classroom environment, "teachers need to provide students with numerous opportunities to solve complex and interesting problems; to

read, write, and discuss mathematics" (p. 427). Several studies and articles have been published indicating that incorporating writing can be an influential source for educators to use inside the mathematics classroom (Banker, 2004; Baxter et al., 2005; Countryman, 1992, 1993; Dougherty, 2006; Grbavac et al., 2003; Koirala, 2002; Kostos & Shin, 2010; Powell, 1997; Thornton-Steele, 2007; Urquhart, 2009).

In 2007, a study (Thornton-Steele, 2007) on *The Effects of Journaling in the Mathematics Classroom* was completed. This mixed methods action research focused primarily on developing writing strategies and techniques that may affect critical-thinking dispositions and problem-solving skills at the high school level. Two different mathematical units were taught in an Algebra I class, pre-test and post-tests were given in both units, and descriptive statistics were examined. While teaching the second unit, concept journals were incorporated in the daily lessons. Based on the statistical data, the study found that students' averages slightly increased significantly. In regard to the qualitative data, as the action research teacher, I "develop[ed] a style of teaching that helped the students flourish" (p. 42). As a result of first-hand observations in-class, I noticed that the students had gained a deeper understanding of mathematics. For example, students would justify their answers, suggest other possibilities, and provide real-world examples that were linked to the concept journaling writing activities. However, the students were not interviewed to expand this research. I relied on the grades of the pre-test and post-tests as indicators of performance and my observations to develop concept journaling from an educator's point-of-view. I have always wondered what the students' voices would have suggested if they were questioned specifically about how writing possibly influenced their individual learning. Through this current research, the goal was to further the understanding of concept journaling and investigate how the cognitive learning elements of language, meaning,

thought, social interactions, and prior experiences influence student learning and how students perceive concept journaling as a tool for learning mathematics.

By the same token, Koirala (2002) explored if mathematics journals were able to facilitate learning of prospective elementary school teachers. The students were required to write weekly (and later bi-weekly) responses to their overall understanding of the mathematics course they were currently enrolled in or respond to a specific mathematical prompt. Utilizing 1800 journal entries from over 200 students, the researcher analyzed the data using constant comparative method and interactive model (p. 219). The researcher found that when students were given just the opportunity to journal, the responses were only a reflection of their thoughts and feelings about the mathematical course. Even when students were encouraged to reflect on their problem-solving strategies, the students reverted to just writing about their thoughts and feelings. It was noted that when students were given specific prompts, more communication was evident throughout the journal writing. Koirala noted that the journals served as a useful tool for thinking for the students and the instructor of the course was able "to understand the mathematical thinking and respond to their concerns" (p. 223), which in turn improved students' mathematical thinking. In relation to concept journaling, through Koirala's research it is apparent that students simply responded with thoughts and feelings about mathematics when they were only given the requirement to simply journal while learning mathematics. Whereas the mathematical problem prompts did give the students specific guidelines of what to journal about, nevertheless, the prompts did not provide a real-world approach for the written application.

Utilizing a more open approach to journaling, Grbavac et al. (2003) employed an action research methodology that utilized pre-student surveys and post-student surveys, teacher observations, and communication surveys. The purpose of their study was to understand if

weekly journaling inside the classroom was a means to increase oral communication between the students and the subject matter and between the teacher and the students. Three different classroom environments (reading, art, mathematics class) at three different grade levels (elementary, junior high school, and high school respectfully) were studied during this research. The researchers noted that when students were given the opportunity to construct and arrange thoughts on paper, the students were more comfortable communicating mathematically during and after the journaling process. When students felt at ease and comfortable with communication, the learning environment became not only more advanced, but also served teachers and students by becoming more relaxed. Furthermore, the researchers noted that "journals are most beneficial to the student, but teachers can use them to become more aware of students' strengths and weaknesses in terms of thinking and learning" (p. 31). During the research study of Grbavac et al., students were given the flexibility of communicating with each other in order to respond to the journal requirement. Yet, the journaling prompt was not focused on real-world mathematical application.

To further examine students' understandings of mathematics, Banker (2004) investigated how journaling and emailing were used to benefit both the teacher and her students on a college campus through qualitative action research. Banker conducted the study with her freshman mathematics course at a local Georgia college to understand how reflective communication via e-journals helped increase overall learning. The students were required to reflect on three questions weekly: "What mathematics did I learn this week? What was easy and why? What was difficult and why?" (p. 36). The research revolved around observing how teaching a class that required e-journals compared to previous courses taught to reflect on how the students' e-journals changed over time, and what the students thought about e-journaling in college mathematics.

From the teacher's perspective, she was able to correct misconceptions almost immediately, future lessons were planned accordingly to accommodate misconceptions, and overall students' success increased during the mathematics course (p. 37). In regard to the students, Banker relied on the students' e-journal replies to create themes on students' writings. Banker argues:

> the students bring with them an undercurrent of attitudes about mathematics that tend to hinder their success. Students often come into these courses with very little confidence in their mathematical abilities. Therefore, one of my instructional goals is to encourage better attitudes toward the study of mathematics, and, consequently, improve student success, and the use of journals has contributed to meeting that goal. (p. 35)

It was noticed that enhanced learning experiences, increased mathematical confidence, receiving immediate feedback, and developing mathematical knowledge from a different perception were witnessed as common patterns among the students who completed the weekly e-journals (p. 38-9). Essentially, Banker was able to hear the students' voices through the e-mail communication and address situations that required attention. Granted, this study did not incorporate real-world application or mathematical prompts that could have potentially allowed the students to further develop mathematical understanding.

Furthermore, and using a more focused approach to real-world mathematics, Baxter et al. (2005) developed a study with the purpose "to examine what writing reveals about low-achieving students' mathematical proficiency" (p. 120). A seventh grade classroom with twenty-eight students in a regular education mathematics classroom with a veteran teacher (Ms. Carter) participated in this study. The study focused on four students who were identified as low achieving and their performance was compared to the remaining students in the classroom. At the beginning of the year, when Ms. Carter introduced writing to her classroom, she first required the students to write about their feelings. As the school year moved forward, her focus changed to more mathematical. Ms. Carter created writing assignments that would (1) relate to the

mathematical topics studied in-class; (2) improve students' awareness of their own thought processes; and (3) facilitate students' personal ownership of knowledge (p. 121). The data for this study was collected from three sources - classroom observation, teacher interviews, and the actual students' mathematical journals. In order to gather data to use for analysis from the students' mathematical journals, a leveling coding system (Level 1 - Level 4) was utilized to assess each individual student's written entries. The assigned rubric level was analyzed with percentages to compare each student's journal entry. In addition, the qualitative data from the observations and interviews were compiled to further understand how communication through mathematical journals were (or were not) effective for low-achieving students.

Baxter et al. (2005) noted that for those students who showed little interest in the course, the journal entries paralleled the observations. For example, the student who consistently responded in the journal with "I do not know" was the same student who would not accept assistance in the classroom and seemed disinterested in the course in general. On the other hand, there were some students who appeared to be interested in the course lecture, but rarely, if ever, commented during the class who utilized the journal to increase their communication with the teacher and further their mathematical understanding. Also, through the observations and interviews, the researchers noticed that the female students were able to connect to the teacher more via journal communication. All students were allowed the opportunity to share their individual knowledge, and students began to shift from being inactive inside the classroom to more active as they began to write (with the use of drawings, symbols, and words) through mathematics. Ms. Carter noted that she was able to gain valuable knowledge regarding the students and what they did and did not know or understand through the journal entries. The research that revolved around Ms. Carter's class incorporated real-world mathematical

application, yet students were not given the flexibility to utilize available resources to help them construct the written response.

In a similar vein, Kostos and Shin (2010) investigated how the use of math journals (*math* was the term used throughout Kostos and Shin research not the term *mathematics*) affected second grade students' communication of mathematical thinking. The researchers allowed students to utilize several resources as they completed an action research project, using mixed methodology (p. 223). Through this action research, the researcher (teacher) collected data utilizing her second grade semi-diverse classroom. With the use of pre-assessments and post-assessments, mathematics journals, interviews with the students, and the teacher's reflective journal during the study, the researcher was able to collect a significant amount of qualitative and quantitative data. At the beginning of the 7-week study, the teacher first gave a mathematical pre-test before she began implementing math journals. As she modeled journaling, she also taught strategies throughout the study; how to increase vocabulary in the writings, how to utilize clues in the journals' prompt, how to consult previous work and textbook(s), and how to successfully explain how a problem is solved step-by-step (p. 226). The math journals were graded quantitatively using *Saxton Math Teacher Rubric for Scoring Performance Task* and qualitatively "using coding and categorizing to examine similarities and differences between responses and common occurrences such as increased math vocabulary use" (p. 227). Eight randomly selected students were interviewed and the responses were analyzed by common themes and patterns. Also, the teacher's reflective journal was evaluated using coding and memo procedures. Finally, the pre-test was administered as a post-test to the participating students.

Scores of the pre-test and post-test were analyzed using a t-test and descriptive statistics. The study found that there was a significant statistical difference between the pre-test and post-

test. The student interviews suggested that as the journaling progressed, they became more comfortable with the expectations, and the students were able to articulate how they used mathematical terms throughout the math journals. This finding aligns with the teacher's reflective journal because she wrote "the students are becoming more adept at writing and needing less assistance" and "detailed explanations are much better; step-by-step explanations include drawings; explanations of what they did to answer the problem" (p. 228). In addition, there was a significant increase in the use of proper mathematical vocabulary throughout the journaling. The teacher was encouraged by what she was able to discover regarding individuals' mathematical knowledge with the use of the math journals. Through this research, Kostos and Shin focused on the process of mathematical problems without the inclusions of real-world application.

Gaps in Literature

There is shortage of literature (Appendix B) that has been published regarding writing in the mathematics classroom in a variety of contexts, using many different methodologies, examining the teachers' perspective of writing in mathematics, and/or evaluating students' writing using a quantitative rubric system. Within the existing body of literature reviewed in this study (Banker, 2004; Baxter et al., 2005; Grbavac et al., 2003; Koirala, 2002; Kostos & Shin, 2010; Thornton-Steele, 2007), there is no written documentation that suggests that journaling in mathematics is not beneficial on some level. The data gathered and analyzed in the studies presented are valued and worthwhile to the pedagogical practices to mathematics education. Many of the authors recognized that overall communication and a greater level of trust were established in the mathematics classroom between the students and teacher with the incorporation of journals. But, the students' voices and perceptions are lacking in the literature.

What are the students' thoughts on their own learning as they engage in writing in mathematics through meaning, language, and thought as they possibly increase their own mathematical knowledge? How do the students perceive writing activities to learn? Missing in the literature is research regarding the students' voice and perceptions in regard to writing in mathematics. As students become more aware of how writing can potentially enhance their overall understanding and comprehension of a subject, the more motivated they are to learn (O'Farrell, 2009). Encompassing several layers of concept journaling in the mathematics classroom, (real-world application; students' written response; students' flexibility to utilize resources; and teacher's response to the process of writing) this qualitative research case study aims to understand how the writing activities influenced student learning in a high school Coordinate Algebra classroom and how students perceived concept journaling as a tool for learning mathematics.

Overview of Concept Journaling

Concept journaling begins with a central idea that allows the writer to potentially generate new knowledge and material, which could provide the opportunity for deeper thinking and the possibility to influence student learning. Concept journaling is defined as a type of writing activity using topic prompts that incorporate graphs, charts, real-world situations, mathematical formulas, diagrams, images, text, or other appropriate resources for the student to communicate and express mathematical thoughts through writing. Concept journaling is a unique writing strategy that encompasses several different aspects of mathematics and writing inside the classroom. The concept journaling process starts with the students receiving a writing activity that requires the students to compose a written and computational response, which incorporates real-world application. Through the concept journaling process, students are given the flexibility to choose the level of interactions with the resources available (i.e. internet, peers, books, etc.) in

order to assist students in completing the written response and the teacher's response to the process of the writing activity. Powell (1997) suggests that while journals provide "students with opportunities to work with mathematical ideas in their own language and on their own terms, writing helps students develop confidence in their understanding of mathematics and become more thoroughly engaged with mathematics" (p. 5); concept journals could potentially provide the same opportunities. The process of concept journaling allows learners the opportunity to fit new ideas together into a scheme. When students are presented with a concept journal that requires them to process learned material differently and make connections with previously learned skills and application of the real-world, they will be more apt to acquire the skill to be applied in the future.

This particular qualitative case study is specifically focused on understanding how the writing activities influenced student learning in a high school Coordinate Algebra classroom and how students perceived concept journaling as a tool for learning mathematics After a mathematical lesson was and taught students had been exposed to instruction using mathematical symbols, graphs, ideas, real-world positioned topics, and open-ended questions, they were then asked to *concept journal* for a specified amount of time, approximately 30–40 minutes of the five hour course (At this particular alternative school, students attend one class per day. Essentially, the students receive a weeks' worth of instruction in one day). I argue that concept journaling allows students the opportunity to understand mathematics by using a writing, graphs, drawings, text, and pictorial models. In addition, the teacher will be able to assess students' problem-solving schemas and skills by requiring them to show their understanding in a variety of ways. For a concept journal to be complete, a student will be required to communicate accurately, use

proper definitions, understand symbol meanings, calculate correctly, and state answers appropriately in hopes that student learning of mathematics will be reinforced.

Supporting the Idea of Concept Journaling. Arguably, a mathematics journal allows students the opportunity to express thoughts, ideas, and feelings into written communication. Based on the previous literature discussed, when students in a mathematics classroom are required (and comply) to maintain their own mathematics journal; the journaling process could facilitate students' understanding of the mathematics concepts. Journaling is a way to link strategies and activities of writing in a way that the students' thought process begins to deepen, and the mathematical ability of students continues to increase (Knapp, 2006). Using journals allows teachers the opportunity to identify the learning needs of individual students, review the appropriateness of curriculum, and evaluate the quality of their own teaching (Borko & Elliot, 1999). In addition, the written communication then provides insight for teachers to facilitate the development of students' critical-thinking, problem-solving strategies, and dispositions about mathematics in general (Dougherty, 1996). The literature supports the idea of concept journaling in respect to what the teachers' and researchers' observe both quantitatively and qualitatively. Furthermore, there is a shortage of research that examines different applications of writing, specifically concept journaling, in the mathematics classroom. These include real-world applications, written responses, flexibility to utilize resources, and teacher response to the writing process. In addition, there is limited literature reporting students' voices and perceptions as they reflect on their learning experiences with writing in the mathematics classroom.

Supporting the Idea of Concept Journaling with Technology. As a society of educators and scholars, we are constantly progressing towards an increased use of technology to help enhance the classroom environments. Several research studies (Applebee & Langer, 2009;

Chapman, 2006; McGrail & Davis, 2011; Worley, 2008) inquire about teachers' and students' perspectives of incorporating technology while writing is implemented to enhance learning. Several studies found that with the use of technology, students were allowed to expand their personal writing skills and process with the use of multimodal texts, (Applebee & Langer, 2009; McGrail & Davis, 2011; Worley, 2008) and students' report writing in academic subjects improved (Chapman, 2006). Furthermore, Chapman (2006) argues that the use of technology allows "connections to children's lives within and beyond the classroom" (p. 38) and technology grants the opportunity to provide "writing tasks that are authentic and appropriately challenging" (p. 39).

The use of technology in every aspect of life is becoming more and more relevant. Technology has been further integrated inside classrooms as it has become more readily available. Some students bring their personal technology (i.e., smart phones, tablets, laptops, etc.) to the classroom or it is provided inside the classroom. It is important to note that the purpose of this study is not the use of technology in concept journaling in the mathematics classroom. However, students will be provided and allowed to use technology tools as needed when completing the concept journal writing activity. The technology resources can be utilized in ways that allow students to further explore the topic, and students will be able to use technology to complete the concept journal in any way that is appropriate.

Summary

This literature review started a review of empirical studies that has employed a symbolic interaction approach through a mathematics classroom. Establishing a definition of writing and learning and how writing impacts learning is presented. In regard to concept journals, one is able to understand how writing is directly related to the highest pinnacle of learning. In addition, the

NCTM (2000) standards and principles were explored to further gain insight into the educational movement towards a learning environment that favors a more focused approach that encompasses writing in the mathematics classroom. Empirical studies on writing in mathematics classrooms have been reviewed in order to demonstrate that the students' voices and perceptions are missing in the literature. The literature provides evidence that writing activities positively influence mathematical learning. The published literature does not convey the influences of writing from the students' voice and/or point-of-view. The idea of a concept journal corresponds to a type of writing activity that can be implemented inside the mathematics classroom.

CHAPTER 3

Methodological Framework

This study employed a case study design. There are multiple definitions of a case study in the literature. For the purpose of this research, a case study will be defined as a detailed empirical examination of one setting, or a single subject, a single depository of documents, or one particular event in a social context (Bogdan & Biklen, 2007; Kohn, 1997; Merriam, 1988; Stake, 1994; Yin, 1989, 1994, 2009). Kohn (1997) argues that one purpose of a case study is "to *describe* a process or the effects of an event or an intervention, especially when such events affect many different parties" (p. 3). In addition, this study employed an action research approach. McNiff (1999) defined action research as the name given to an increasingly popular movement in educational research that encourages teachers to be reflective of their own practices in order to enhance the quality of education for themselves and their students. Furthermore, action research is a form of self-reflective inquiry that can be used in school-based curriculum development, professional development, and school-improvement schemes. Kostos and Shin (2010) suggest that "the researcher/teacher [will be] able to utilize the insights that can only be obtained as an insider to the setting. The insider insight [will] help the researcher capture the students' thinking process more closely and gather and analyze the data more in-depth" (p. 226). Simply stated, my goal as the researcher was to actively engage myself in the classroom context in order to improve educational learning by utilizing concept journaling writing activities with the students. As the researcher, I was able to gain firsthand knowledge of the process of concept journaling and how writing influences student learning in the mathematics classroom and how the students perceived concept journaling as a tool for learning mathematics.

General characteristics of a case study revolve around the types of case study (explanatory, exploratory or descriptive), design (single or multi-case), and method (qualitative, quantitative, or mixture of both). In regard to the types of study, the purpose of an explanatory case study is to gather information concerning two (or more) variables and look for relationships among these variables, whereas an exploratory case study allows the researcher to gain a better understanding of a topic, subject, or problem (Yin, 1994). The overall intention of exploratory research is to recognize significant issues and variables within the study. A descriptive case study provides an accurate explanation of a particular event observed/studied. The design references the number of cases that are being studied. A single case study is used to verify or dispute a theory, and a multiple-case study allows the researcher to gather data from a variety of sources and suggest conclusions based on the evidence (Yin, 1994). Finally, the method refers to the process used to collect data for the research. Yin (1994) suggests that there are six data collection sources for evidence: documents, archival records, interviews, direct observations, participant observations, and physical artifacts. For the purpose of this study, a qualitative exploratory multi-case study approach was utilized based on interviews, observations, and physical artifacts (concept journals and researcher/teacher's journal) in order to come to a conclusion based on the evidence gathered that support the purpose and research questions.

Exploring case study in-depth, Yin (2009) outlines five components that are important for all case study designs: the questions, propositions (if any), units of analysis, logic linking the data to the propositions, and criteria for interpreting the findings. When the research questions are composed, Yin (2009) suggests that a case study research is effective when "(a) a 'how' of 'why' question(s) are being posed, (b) the investigator has little control over events, and (c) the focus is on a contemporary phenomenon within a real-life context" (p. 2). The study

propositions are cultivated out of the scope of the research; but based on the type of case study, not all case studies have propositions. For example, an exploratory study will not have a proposition because the purpose of the study will be stated in the design since the topic is the focus of "exploration". The unit of analysis is embedded in the overall foundation of the case being studied such as an individual, a group of people, or an entire team. The last two components, logic linking the data to the propositions and criteria for interpreting the findings, foreshadow the data analysis in a case study research. In order to link the data to the propositions, the research question(s) must be connected to how data is collected throughout the study. Finally, the criteria for interpreting a study's findings require the researcher to identify and address rival explanations for the qualitative findings (Yin, 2009, p. 34).

Research Classroom Setting and Demographics of Participants

This qualitative case study took place at a small (the total population ranges from thirty to one hundred students) alternative high school in a suburb of the southeastern United States. Table 1 shows the current student population in regard to gender and race/ethnicity for this study for the 2014-2015 academic school year.

Table 1

Student Population

Gender	Race/Ethnicity				
	Hispanic/Latino	Black/African American	White	Two or More Races	Total
Male	3	22	19	1	45
Female	0	11	5	0	16
Total	3	33	24	1	61

Note. This data was collected from school webpage, Infinite Campus.

As shown in Table 1, the population at the beginning of the research total was 61 students with 74% males and 26% females. The population during the implementation of the study consisted of "Hispanics/Latino", "Black/African American", "White" and, "two or more races".

According to school statistics at the beginning of this research study, the most common race/ethnicity was "Black/African American," with 54% of the students identifying as such followed by 39% identifying as "White" 5% identifying as "Hispanic/Latino", and 3% identifying as “two or more races” . This alternative high school is for students who currently reside within the county and who have been placed in this school by student services (base school administration, counselor(s)/social worker(s), Department of Juvenile Justice Judge/probation officer(s), teacher(s), and/or alternative school administration). The students who are enrolled in this alternative high school are placed for (1) minor incidences such as implementation of a safety plan, constant behavioral referrals, and/or fighting, and/or for (2) major incidences such as possession of drugs or alcohol, and/or after committing felony crimes and/or serving jail time. Some of the students are placed for the remainder of the 9-weeks, a semester, a full year, or all four years of high school. At any time more than half of the students are on probation. There are eight certified teachers, four paraprofessionals, a counselor, and principal. The academic levels of the enrolled students vary, just like at a traditional high school. There are no differences between the course requirements of the students at the traditional base public high schools versus the alternative public high school. The students at the alternative high school are held to the same standards and graduation requirements as those at any other public high school in the state. For example, every student in the state is required to complete the Coordinate Algebra course to receive one of four mathematics credits that are needed in order to graduate from public high school.

I selected one Coordinate Algebra mathematics class to participate in the research. This particular class was asked to participate because the students’ overall attendance rate was higher than the other classes of Coordinate Algebra courses I taught. The class included seven students

from diverse backgrounds, different grade levels, and various ages. When the students were present they participated in the concept journaling writing activities, discussions, and interviews. Table 2 lists each student's initials, age, race, sex, and the number of previous Coordinate Algebra classes each student was enrolled in and not passed.

Table 2

Demographics of Participants

Initials	Age	Race	Sex	Previous Coordinate Algebra
RC	14	White	Male	None
RD	16	White	Male	Two
SH	15	White	Male	None
CM	15	White	Male	None
MR	14	White	Male	None
RS	16	Hispanic	Male	One
TS	17	Black	Female	Two

Procedure and Timeline for Intervention and Research Completion

I approached the principal of the school to inform him of the purpose, duration, and how students would be involved with the study. The study was conducted in one Coordinate Algebra class for 7 weeks. Students were informed that participation was voluntary and being in the study would not influence their grade in the class. Students and parents/guardians were asked to sign assent and consent forms acknowledging participation in this research study (Appendices C and D). In addition, Institutional Review Board (IRB) approval at the university level (Appendix E) and at the county level were solicited before the study was conducted and the IRB regulations were adhered to for the duration of this study.

After receiving necessary permissions, one Coordinate Algebra class that I (the researcher and teacher) taught during the implementation of the study was selected to participate. Before data collection began, I discussed in detail with all students the purpose of this study, the research questions, and the methods of gathering evidence. At the beginning of the study,

students were pre-interviewed to explore their personal views on writing in connection to learning (see Appendix F for interview questions). The pre-interview was audio recorded and transcribed. The students were introduced to concept journaling through a class discussion. Before a concept journal writing activity was assigned, I taught a lesson (for approximately 30–50 minutes) and students participated by taking notes, solving problems, engaging in the class discussions and connecting the mathematics concepts to real-world applications. At the end of instruction, students were assigned a concept journal writing activity related to the Coordinate Algebra lesson taught. The activity was read aloud to the class. Students became accustomed to concept journaling by engaging in a series of 30–40 minutes concept journal writing activities (see Appendix A for concept journal writing activities). As students engaged in the concept journal writing activity, I observed and documented their involvement and actions (i.e., Did the students actively engage in writing? Did the students utilize available recourses such as notes, technology, textbook, etc?). In addition, students were encouraged to create drawings, charts, pictures, graphs, text, etc. in order to further assist them in expressing their ideas to the concept journal writing activity. At the end of each class session, concept journals were collected for further investigation. This cycle of teaching, assigning a concept journal writing activity, and observating occurred one to two times during a class session (a block of 2 hours). The concept journals were analyzed for evidence of student learning by examining constructions of meaning, language, and thought. As the students were immersed in written dialogues, they were encouraged to constantly reflect on the process of incorporating concept journaling in mathematics and how they perceived concept journaling as a tool for learning mathematics. These reflections would be captured through informal discussions. As the research came to a close, post interviews were conducted to gain an in-depth understanding of student perceptions

of concept journaling as a tool for learning mathematics (see Appendix F for interview questions). The post-interview was audio recorded and transcribed. The transcribed interviews, students' concept journals, observations, and research/teacher's journal, were analyzed to extract major patterns and themes indicative of student overall learning and student perceptions of concept journaling as a tool for learning mathematics. Table 3 provides a timeline for intervention and research completion.

For this series of concept journal writing activities, the mathematical lessons revolved around the Common Core Georgia Performance Standards (CCGPS) for Coordinate Algebra Unit 3: Linear and Exponential Functions. The key standards addressed throughout the lessons were: (1) represent and solve equations graphically and solved using real-world context, (2) understand the concept of a function and use function notation, (3) interpret functions that arise in applications in terms of the context, (4) analyze functions using different representations, (5) build new functions from existing functions, (6) construct and compare linear and exponential models and solve problems, and (7) interpret expressions for functions in terms of the situation they model. In addition, the following concepts and skills needed to be maintained throughout the unit: (1) know how to solve equations, using the distributive property, combining like terms and equations with variables on both sides, (2) know how to solve systems of linear equations, (3) understand and be able to explain what a function is, (4) Determine if a table, graph or set of ordered pairs is a function, (5) distinguish between linear and non-linear functions, and (6) write linear equations and use them to model real-world situations (Common Core State Standards Initiative, 2010; Georgia Department of Education, 2014).

Table 3

Timeline for Intervention and Research Completion

Month	Week	Research Activity
January	1	Planning and meeting with Principal
	2	Administering consent and assent forms
		Overview of Research with participants
	3	Pre-Interview
		Observation
		Concept Journal A
		Informal Discussions
		Collecting and analyzing student work and observation
		Synthesizing data
	4	Concept Journal Writing Activity
		Observation
		Concept Journal B
		Informal Discussions
		Collecting and analyzing student work and observation
		Synthesizing data
		Writing the dissertation
February	5	Concept Journal Writing Activity
		Observation
		Concept Journal C and Concept Journal D
		Informal Discussions
		Collecting and analyzing student work and observation
		Synthesizing data
		Writing the dissertation
	6	Concept Journal Writing Activity
		Observation
		Concept Journal E and Concept Journal F
		Informal Discussions
		Collecting and analyzing student work and observation
		Synthesizing data
		Writing the dissertation
	7	Post-Interview
		Observation
		Collecting and analyzing student work and observation
		Synthesizing data
		Writing the dissertation

Data Collection Techniques and Units of Analysis

Multiple data sources were utilized to ensure that this research study could provide an in-depth understanding of how concept journal writing activities influenced student learning and

how students perceived concept journaling as a tool for learning mathematics (Table 4 shows the data collection matrix). The data collected from all sources were used to corroborate the findings through triangulation. Kohn (1997) suggests that:

> The concept of triangulation dictates that the researcher uses multiple methods for collecting and analyzing data so that all sources converge on the facts of a case. This means that multiple kinds of data sources and multiple respondents need to be built into the design of the study. (p. 7)

Data was triangulated using four qualitative techniques: interviews, observations, student concept journals, and teacher/researcher's journal.

Table 4

Data Collection Matrix

Research Question	Sources of Data
1. In what ways does the use of concept journaling, as a writing activity, influence student learning in a high school Coordinate Algebra mathematics classroom?	Interviews Observations Concept Journals Researcher/Teacher's Journal
2. In what ways do student perceive concept journaling as a tool for learning mathematics?	Interviews Observations Researcher/Teacher's Journal

Interviews. During the third week of the study (one pre-interview before concept journaling was implemented) and during the seventh week (one post-interview at the completion of the research of concept journaling) of this study, I informally interviewed the students for approximately five minutes. I asked several questions regarding their learning (see Appendix F for interview questions). The purpose of the pre-interview was to establish some baseline data regarding students' personal views of writing in connection to learning. The purpose of the post-interviews was to further gather data regarding the students' voices and to help understand how

students perceive concept journaling as a tool for learning mathematics. The interviews were audio recorded and transcribed. In addition, the researcher/teacher wrote notes, observations, and reflections in the researcher/teacher's journal for the duration of the interviews. All students who were on the current roster and who were present in the classroom were asked to participate in the interviews. When the opportunity arose, I conducted informal discussions with the students regarding writing, concept journaling, and mathematics throughout the study.

Observations. The researcher conducted classroom observations during each concept journal activity from January 2015 to February 2015 (see Appendix G for observation log). The weekly observations took place while the students were completing the concept journal writing activity in the classroom. As students engaged in the concept journal writing activity, I documented their involvement and actions (i.e., Did the student actively engage in writing? Did the students utilize the provided in-class resources such as notes, technology, textbook, etc.?). The notes for each observation were recorded in the researcher/teacher's journal. Through the observations I was able to triangulate the data gathered from the interviews and concept journal writing activities.

***Concept Journals*.** The students were assigned a concept journal writing activity, for a total of six completed concept journals (see Appendix A for concept journal writing activities). The allotted time for each concept journal writing activity was 30–40 minutes. The concept journal writing activities were directly linked to the material that was currently taught (for example, linear and exponential functions). Therefore, the classroom time was used efficiently in order to effectively incorporate a writing activity that could be perceived as a tool for learning mathematics. The students were able to use any classroom resources (technology, internet, textbook, class notes, etc.) that could assist them in responding to the concept journal writing

activity. The concept journal writing activities were examined by the researcher/teacher to further explore the students' thoughts, meanings, and language; to check for understanding; and to demonstrate mastery of mathematics. All concept journal writing activities were collected at the end of the class for which it was assigned and were kept in a designated folder in the researcher/teacher's desk.

Researcher/Teacher's Journal. The researcher/teacher's journal was used to record gathered data from the audio taped transcribed interviews, the teacher/researcher's observations, the reflections of the concept journals, the daily reflections of teaching writing through concept journaling in Coordinate Algebra, teacher introspection, etc. The researcher/teacher constantly observed the classroom while the students were engaged in the concept journaling writing activity. In addition, a written reflection was provided after reading the students' responses to the concept journal writing activities. The researcher/teacher's journal was utilized in order to further understand the students' perceptions of writing in mathematics.

Data Analysis

Data analysis focused on comparing and contrasting themes that emerged through a detailed examination of the transcribed verbal pre-interviews and post-interview, observations, concept journal writing activities, and documentation in the researcher/teacher's journal. There were two units of analysis: concept journals and student perceptions. Through the written concept journal entries, I investigated how the concept journal writing activities influenced student learning and the understanding of the concepts (linear functions, exponential functions) with the incorporation of writing in the mathematics classroom. Stake (1994) states that:

> case researchers seek out both what is common and what is particular about the case, but the end product of the research regularly portrays more of the uncommon drawing all at once from the nature of the case, particularly its activity and function…and those informants through whom the case can be known. (p. 447)

Specifically, I explored the written text, through concept journals, in order to provide evidence indicating whether or not students developed a deeper level of understanding in regard to mathematical concepts, application of topics to past lessons learned, link concepts to the real-world, and problem-solving strategies. Writing is known to be a higher-order thinking skill which corresponds to the top three tiers of the original Bloom's Taxomony: evaluation, synthesis, analysis.

Emig (1997) advises that "writing serves learning uniquely because writing as process-and-product possesses a cluster of attributes that correspond uniquely to certain powerful learning strategies" (p. 122). To further elaborate the argument that writing is the highest form of learning, Morrison, Ross, and Kemp (2001) created a table (Table 5) which outlines action verbs that correspond to the top three tiers of cognitive levels of Bloom's Taxonomy. These action verbs are directly related to writing. Therefore, each concept journal was reviewed for when students were able to appraise, compare, explain, organize, categorize, analyze, investigate, illustrate, etc., throughout the writing activity. The correlation between writing and the action verb is correlated with the top levels of Bloom's Taxonomy.

Table 5

Bloom's Taxonomy - Cognitive Domain

Cognitive Level	Definition	Action Verbs
Evaluation	To judge the quality of something based on its adequacy, value, logic, or use	appraise, compare, contrast, criticize, describe, explain, justify, interpret, support
Synthesize	To create something, to integrate, ideas into a solution, to propose, an action plan, to formulate a new classification scheme	create, categorize, devise, design, explain, organize, plan
Analysis	To identify the organizational structure of something; to identify parts, relationships, and organizing principles	analyze, diagnose, investigate, differentiate, distinguish, illustrate, select, separate

In addition, through the verbal interviews, I wanted to depict and document the students' voices regarding how they perceived concept journaling as a tool for learning mathematics. These documents (interviews, observations, concept journals, and researcher/teacher's journal) became reflective narratives providing a description of the participants' and researcher/teacher's introspection of how incorporating concept journaling inside the mathematics classroom could influence student learning (Bogdan & Biklen, 2007).

In order to code, categorize and generate concepts from the data gathered, a generic protocol was utilized as suggested by Lichtman (2013, p.252).

The six steps provided from Lichtman are as follows:

Step 1: Initial coding. Going from responses to summary ideas of the responses
Step 2: Revisiting initial coding
Step 3: Developing an initial list of categories
Step 4: Modifying initial list based on additional readings
Step 5: Revisiting your categories and subcategories
Step 6: Moving from categories to concepts

In order to initiate each step and move from Step 1 to Step 6, Lichtman provides a brief overview of how to complete each step. As the researcher begins (Step 1) to read and reread the

collected data, initial codes became noticeable to establishing a list of several initial codes. The goal of Step 2 was to rename synonyms, clarifying focus by removing redundancies, or clarifying words in order to select a term that portrays the characteristic. With the revisions of the codes, Step 3 was the beginning of creating and organizing the codes into categories. Lichtman encourages the researcher to again return to the original list of codes and categories (Step 4) in order to combine, dismiss, and/or separate codes and categories as needed. As the process of Step 1 through Step 4 came to a close, Step 5 was the beginning of identifying critical elements of the data utilizing the revisited codes and categories that were created in the previous steps. And the final step, Step 6, allowed the researcher to identify key concepts that reflected the meaning attached to the data collected (p. 254). It is apparent that Lichtman provides the researcher the opportunity to be subjective with analysis of the data collected as the researcher moves from coding initial data through identification of categories to the recognition of important concepts or themes (p. 254).

Data from the transcribed interviews, observations, completed concept journals, and researcher/teacher's journals were examined for evidence of meaning, language, and thought in regard to mathematics learning. Using Lichtman generic 6-step coding, I extracted initial list of codes (Step 1), then I simplified and condensed the list (Step 2) in order to create more well-rounded and descriptive terms that responded to the research questions. I then began to place the codes into designated categories (Step 3). As I reread through the codes and categories (Step 3), I became more aware of codes that needed to be discarded, combined, or separated (Step 4). I began to recognize significant aspects of the data (Step 5) using the codes and categories from Step 1 through Step 4. Furthermore, I distinguished significant concepts that possibly revealed

evidence of meaning, language, and thoughts (Step 6) as students engaged in the process of concept journaling inside the mathematics class.

Validity and Reliability

The validity of this research was insured by aligning data collection with the research questions. Data was triangulated using multiple sources (interviews, observations, concept journals, and researcher/teacher's journal) which facilitated a deeper understanding of the influences of concept journaling on student learning and student perceptions. Kohn (1997) suggests that methods used for validation is triangulation. In order to report authentic experiences, students were given the opportunity for member reflections; therefore, students had the opportunity to give me feedback on the analysis and conclusions I came to through organizing their thoughts and perceptions regarding concept journaling (Tracy, 2010). As the researcher/teacher, I understand there might have been inherent biases that one may assume because I fulfilled both roles during this study. However, it is anticipated that with the triangulation of the research data and member-reflections, findings are parallel in all circumstances. Also, reliability has been established through describing in detail the process concept journaling and how the procedure would be consistently documented.

Trustworthiness, Credibility, and Transparency

To ensure the trustworthiness of this qualitative research, credibility and transferability plans were established and utilized. Credibility essentially refers to how congruent the findings are with reality (Shenton, 2004); therefore, multiple data sources were utilized to determine if similar themes appeared and were published within the literature. In order to further establish credibility of the research, an adoption of established research methods were utilized to conduct this study. In addition, I have truthfully portrayed my classroom, the students, and the culture of

the school throughout the study. I have provided an accurate description of the learning environment and discussed my role as the researcher of this study and teacher of this class. The population of this school has been provided in conjunction with the sample of students who were selected to participate in this research. Throughout the study, participants were encouraged to be honest in order for their accurate perceptions to be represented in the findings. Also, I have described the uniqueness of this alternative school in regard to how students are enrolled and the daily scheduling of coursework for the students.

Ethics and Confidentiality

Chambliss and Schutt (2012) suggest four guidelines that cover ethical issues in research: (1) protect participants, (2) maintain honesty and openness, (3) achieve valid results, and (4) encourage appropriate application. In order to protect students and ensure confidentiality, students' names were kept anonymous throughout the research process with the use of initials for identification purposes. All paper documents (consent forms, observations, reflections, concept journal writing activities, researcher/teacher's journal, etc.) were stored in a locked cabinet in the classroom during the study and at the researcher/teacher's home after the study was completed. In addition, all electronic documents were saved on my personal secure computer. Throughout the process of this research, I have been open in disclosing my methods and honest in presenting the findings (Chambliss & Schutt, 2012, p. 53). Valid results were anticipated because the research was conducted in a professional, accurate, and systematic manner as the associate between the data and conclusion will be presented (Bapir, 2012). And finally, after this research study is completed, appropriate application in regard to the way this research is used is encouraged.

Summary

The overall goal of the study was to investigate the influences of concept journaling on student learning and the way students perceived concept journaling as a tool for learning mathematics. During the implementation of this case study, I have provided a thorough explanation of the methodological framework (Bogdan & Biklen, 2007; Kohn, 1997; Merriam, 1988; Stake, 1994; Yin, 1989, 1994, 2009), justified the data collection technique, detailed the units of analysis, and supported how the analysis of the data would transpire (Lichtman, 2013). In conclusion, Hostetler (2005) suggests that as the classroom teacher, I had a unique involvement with the study because I was also the action researcher. Yet, I tried to bracket myself as much as possible for the duration of the research study. In order for the research to maintain validity, I provided understanding of how data collection techniques corresponded with the research questions, how data would be triangulated and how member-reflections would be employed in this research. In addition, reliability was established though consistent record keeping, documentation of the overall research procedures, and indication of the operations of the study. In order to preserve trustworthiness throughout this study, I have revealed my role as the researcher and teacher, the learning environment of the classroom, the alternative school, and the participants of the study. For credibility and transferability to be sustained, established research methods have been employed, multiple data sources were used to collect data, and multiple resources were utilized to compare this research to published literature. Finally, ethics and confidentiality were safeguarded because I have respected the research process, maintained high standards for myself as the researcher of this study and teacher of this class, implemented necessary protocols to protect the participants of this study, and I vowed that this research will be used in only appropriate application.

CHAPTER 4

Results

The purpose of this study was to examine how writing using concept journaling influences student learning in a high school Coordinate Algebra mathematics classroom and how students perceive concept journaling as a tool for learning. The study used a qualitative case study methodology using action research techniques. In order to examine the learning of seven high school students in one Coordinate Algebra class, data was triangulated using four techniques: interviews, observations, students' concept journals, and researcher's reflections. This chapter provides an overview of the analysis methods and a detailed examination of the major themes that emerged and that describe the influences of writing using concept journaling on student learning and student perceptions of learning. This chapter also includes interpretation of the research findings as guided by symbolic interactionism framework. The study was guided by the following questions:

1. How does the use of concept journaling, as a writing activity, influence student learning in a high school Coordinate Algebra mathematics classroom?
2. In what ways do students perceive concept journaling as a tool for learning mathematics?

Methods of Analysis: An Overview of Coding

Yin (2014) provides several principles to be addressed when analyzing case study research. First, Yin suggests that the researcher must attend to all of the evidence. For this research study, concept journals were the basic unit of analysis examined to gain insight into how the writing activity possibly influenced students' learning in a high school Coordinate Algebra mathematics class and how students perceived concept journaling as a tool for learning

mathematics. Student interviews, observations, and the researcher/teacher's journal were analyzed to elucidate the process of constructing thought, meaning, and language as students engage in active learning.

Furthermore, Yin (2014) advises that the researcher address the most significant aspects of the research. Using the generic 6-step protocol suggested by Lichtman (2013), the initial codes, categories, and concepts were extracted to find emerging themes throughout the analysis of the data. Based on the researcher/teacher's interpretations and introspect, the data gathered from transcribed interviews, concept journals, observations, and researcher/teacher's journals were hand coded to create categories and generate concepts. Sticky notes were utilized to identify critical indicators of learning on several instances: (1) when students engaged in conversation and interactions, (2) when pictorial representations including diagrams and graphs were used and/or created by the students, (3) when meaning was constructed, (4) when prior knowledge was employed, (5) when learning developed, (6) how the real-world was represented through connections and associations, (7) how and when resources were employed to assist the student in completing the concept journal writing activity, (8) how students identified occurrences of learning, and (9) how students perceived themselves as learners through writing.

Finally, Yin (2014) encourages the researchers to use their own prior knowledge when analyzing the data. This case study utilizes action research techniques as I was the teacher of the Coordinate Algebra class and the researcher who conducted the study. My prior teaching experience has provided insight on major indicators of learning and problem solving. As Saldaña (2012) explains, the level of personal involvement filters how the researcher perceives, documents, and codes the data. Hence, my prior experiences as a mathematics educator have guided me throughout the analysis process.

Saldaña (2012) argues that "the act of coding requires that you wear your researcher's analytic lens. But how you perceive and interpret what is happening in the data depends on what type of filter covers that lens" (p. 6). Throughout this study, the lens I looked through was the teacher and researcher lens guided by the three major tenets of symbolic interactionism: meaning, thought, and language. The generic 6-step protocol suggested by Lichtman (2013) for categorizing and generating concepts from the data gathered was utilized in order to analyze the collected data.

Step 1: Initial coding. Going from responses to summarize ideas extracted from responses. In qualitative research, a code is "often a short word or phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language based-or visual data" (Saldaña, 2012, p. 3). I coded the data as it was collected from the very beginning of the study. According to Saldaña (2012), data coding is a unique way to employ "an exploratory problem-solving technique without a specific formula to follow" (p. 8). From this initial step, 46 initial codes transpired: (1) language and communication, (2) classroom discussions, (3) real-world, (4) meaning of mathematics, (5) thinking through problems, (6) classifying levels of learning as per Bloom's Taxonomy, (7) prior knowledge, (8) student relying on resources, (9) classroom instruction, (10) writing to learn, (11) supporting answers, (12) learning to write, (13) perceptions, (14) analysis, (15) organized, (16) interpretation, (17) graphs, (18) flexibility of learning, (19) self assessment of meaning, (20) social environment, (21) making meaning, (22) thought process of students, (23) learner, (24) ease of writing, (25) peer involvement, (26) justification, (27) reading, (28) classroom, (29) synthesize, (30) learning, (31) evaluate, (32) illustrate, (33) equations, (34) functions, (35) compare/contrast, (36) formulas, (37) personal views, (38) self-awareness, (39) social connections, (40) experiences, (41) process,

(42) representation, (43) building associations of ideas, (44) feedback, (45) finding meaning, and (46) mathematics connections.

Step 2: Revisiting initial coding. As stated by Saldaña (2012), "coding is a cyclical act [and] rarely is the first cycle of coding data perfectly attempted" (p. 8). After initial codes were extracted, I worked towards collapsing codes into consolidated and refined clusters. For example, the code classifying levels of learning as per Bloom's Taxonomy was used to further identify any coding that was related to the different levels of learning (evaluating, synthesizing, and analyzing). In addition, the action verbs related to each of these levels (as shown in Table 3) were also placed under Bloom's Taxonomy. The mathematics terms (graphing, functions, equations, and formulas) were all recoded in relation to meaning of mathematics. Classroom discussions and instruction were coded under language and communication. From this step, I was able to combine codes into categories in order to focus on the relevant and significant features emerging from the qualitative data.

Step 3: Developing an initial list of categories. As the coding continued, the codes were clustered together into categories based on inherent commonalities. As a result, an initial list of categories related to student learning and student perceptions was established. At this stage, the codes were preliminary reorganized into two major categories: student learning and student perceptions.

Step 4: Modifying initial list based on additional readings. During this step, the initial codes (Step 1) were reviewed to refine the list and potentially add/combine or dismiss codes if needed. As suggested by Saldaña (2012), the initial "codes may be later subsumed by other codes, relabeled, or dropped all together" (p. 10). As a result, 46 initial codes were consolidated into 24 codes: (1) language and communication, (2) real-world applications, (3) meaning of

mathematics, (4) thinking through problems, (5) building association and ideas, (6) prior knowledge, (7) reliance on resources, (8) writing to learn, (9) learning to write, (10) flexibility of learning, (11) use of multiple representations, (12) social environment, (13) finding meaning, (14) constructing meaning, (15) inferring thought processes, (16) focus on learner, (17) peer involvement, (18) classroom factors, (19) learning experiences, (20) personal views/ideas, (21) self-awareness, (22) social connections, (23) mathematics connections, and (24) process.

Step 5: Revisiting categories. From the previous step, categories were further aligned to describe the data collected. Based on the guiding research questions, the codes were categorized to provide evidence for student learning or student perceptions. Using the modified list, the codes were clustered within corresponding categories. For student learning, 14 codes: (1) language and communication (2) building association and ideas, (3) prior knowledge (4) reliance on resources, (5) flexibility of learning, (6) use of multiple representation, (7) finding meaning, (8) constructing meaning, (9) classroom factors, (10) peer involvement, (11) learning experiences, (12) personal views/ideas, (13) social connections, and (14) process. For student perceptions, 13 codes: (1) real-world applications, (2) meaning of mathematics, (3) thinking through problems, (4) writing to learn, (5) learning to write, (6) inferring thought processes, (7) focus on learner, (8) language of mathematics, (9) learning experiences, (10) self-awareness, (11) social connections, (12) mathematics connections, and (13) process.

Step 6: Moving from categories to concepts to themes. During this step, the major salient codes were arranged in a systematic order to further classify coded data into "families" as they share “some characteristic - the beginning of a pattern" (Saldaña, 2012, p. 8). Using the first five steps, the patterns materialized, and the codes were clustered together to identify the emerging themes as shown in Table 6.

Table 6

Categories to Concepts to Themes

Category	Concepts	Themes
Student Learning	1. Building Associations of Ideas 1. Learning Experiences 1. Prior Knowledge 1. Process 1. Finding Meaning	1. Through concept journaling, students learned by building associations of ideas utilizing their prior knowledge and experiences.
	2. Use of Multiple Representations 2. Making Meaning 2. Reliance on Resources 2. Flexibility of Learning 2. Process	2. Concept journaling created a space for negotiating meaningful connections using multiple resources.
	3. Language and Communication 3. Peer Involvement 3. Social Environment 3. Process 3. Personal Views/Ideas 3. Classroom Factors 3. Constructing Meaning	3. Concept journaling provided opportunities for constructing meaning in context via peer communications and exchanges of personal views and ideas.
Student Perceptions	4. Process 4. Learning Experiences 4. Meaning of Mathematics 4. Real-World Application 4. Thinking Through Problems	4. Students saw concept journaling as a meaningful experience to further their understanding of mathematics using real-world applications.
	5. Focus on Learner 5. Process 5. Self-Awareness 5. Writing to Learn 5. Social Connections 5. Inferring Thought Processes 5. Meaning of Mathematics 5. Learning to Write	5. Concept journaling was viewed by students as a medium to develop an awareness of the self while immersed in meaning making contexts.
	6. Focus on Learner 6. Mathematics Connections 6. Writing to Learn 6. Learning to Write 6. Language of Mathematics 6. Construction of Meaning	6. Students expressed a sense of connection to mathematics through the use of concept journaling writing activities.

Emerging Findings

Six themes emerged as a result of data analysis providing evidence in regard to student learning and student perceptions.

Student Learning:

1. Through concept journaling, students learned by building associations of ideas utilizing their prior knowledge and experiences.
2. Concept journaling created a space for negotiating meaningful connections using multiple resources.
3. Concept journaling provided opportunities for constructing meaning in context via peer communications and exchanges of personal views and ideas.

Student Perceptions:

4. Students saw concept journaling as a meaningful experience to further their understanding of mathematics using real-world applications.
5. Concept journaling was viewed by students as a medium to develop an awareness of the self while immersed in meaning making contexts.
6. Students expressed a sense of connection to mathematics through the use of concept journaling writing activities.

Student Learning

Theme 1: Through concept journaling, students learned by building associations of ideas utilizing their prior knowledge and experiences. Utilizing the classification of learning levels as proposed by Bloom's Taxonomy, Figure 3 and Figure 4 provide evidence of how students *supported* the given data with a real-world example, *organized* data on a graph, *illustrated* the table on a graph, and *described* the features of the linear function.

Given the following table

x	1	2	3	4
y	5	10	15	20

- **Create a real-world example of what this data could represent**

The Football tickets are $5 a person. 1 person buys 1 ticket for $5. 2 people cost $10. 3 people cost $15. 4 people cost $20

Figure 3. M.R. created a real-world example of what the date could represent that was provided in the table.

- **Graph the data**

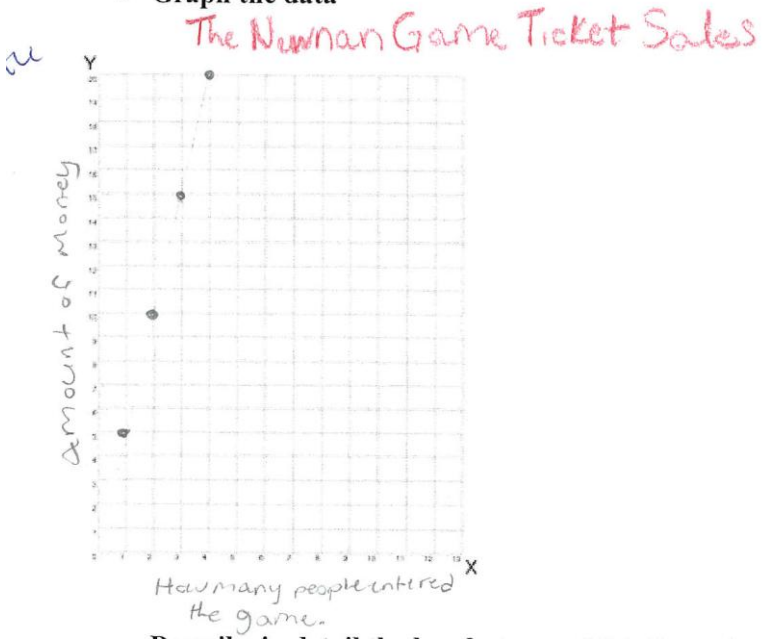


Figure 4. M.R. used the data provided and real-world example created in Figure 3 to illustrate the scenario on a graph.

As illustrated through Figure 3 and Figure 4, given the x/y table, M.R. focused on prior knowledge and his current real-world awareness to provide an example of what the data could represent (e.g. ticket sales, cost of people riding the bus). I asked M.R., whose work is presented, why he selected the example of ticket sales. He explained that recently he and his mother had to collect money at a football game. This experience was fresh on his mind, and he found it relevant to this mathematical problem. It has been argued in the literature on problem solving that the

starting point for students to create meaning is with making links between the individual and his/her experiences with the real-world. In this regard, Svensson, Anderberg, Alvegard, and Johansson (2009) explained "thus the relation itself is seen as coming first when it comes to understanding learning and knowledge. And this understanding, in our view, should be based on the observation of the relation between the individual and his/her world" (p. 210). This type of learning that emerged through making associations with prior knowledge and experiences was also evident in responses shown in Figure 5 and Figure 6 (below). These answers show connections that M.R. made by representing real-world experiences using algebraic concepts. Also, M.R. displayed data presented in the table in a graph to visually represent the value of the numbers on the graph.

Moreover, Figure 5 and Figure 6 show a group work effort where two of the students *criticized*, *explained*, and *justified*, the components of the written automobile contract they *created* and how they *supported* their narrative using multiple modalities, such as a graph and table.

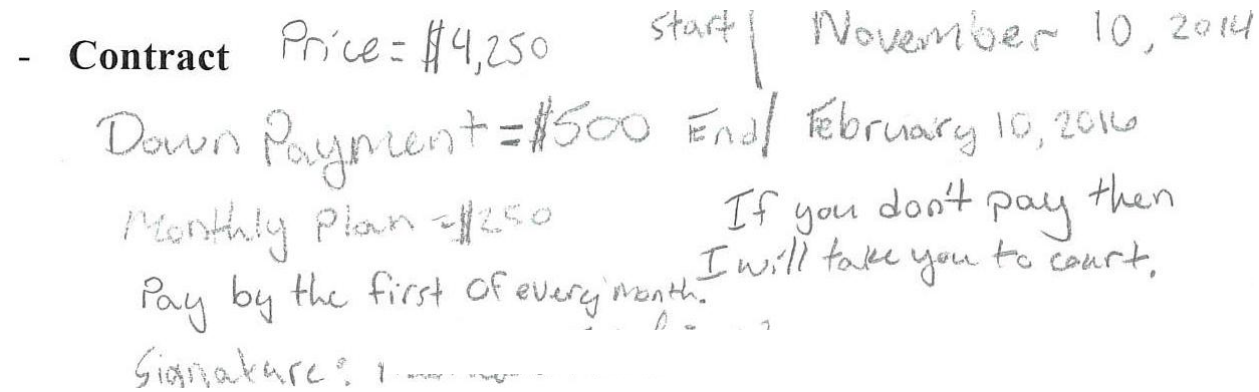
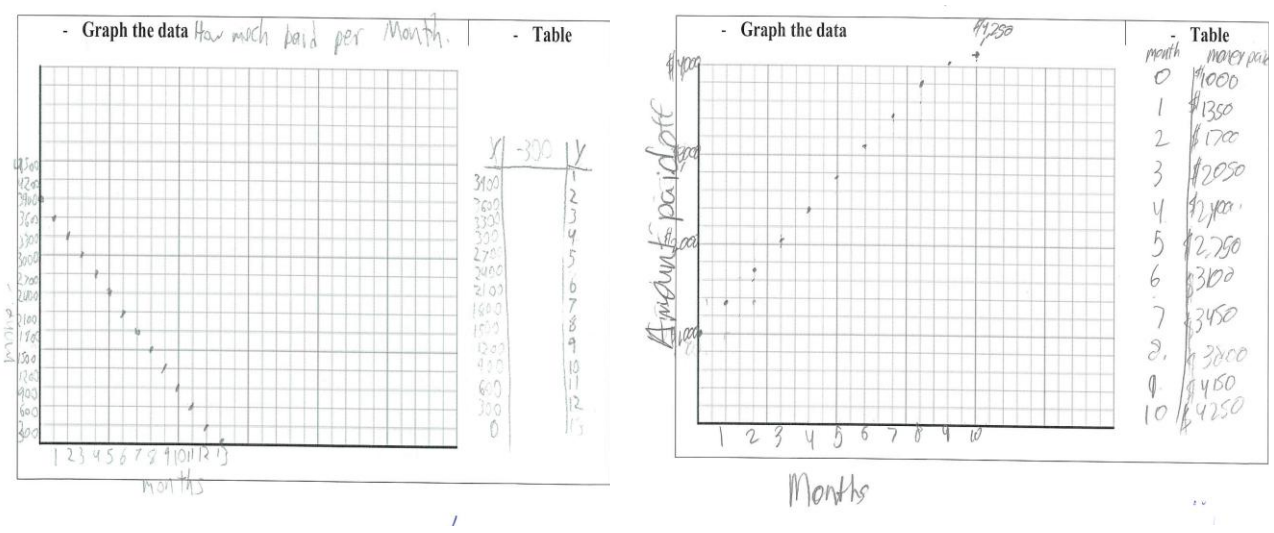


Figure 5. M.R. wrote a contract for selling an automobile based on information provided from the writing activity.



a. b.

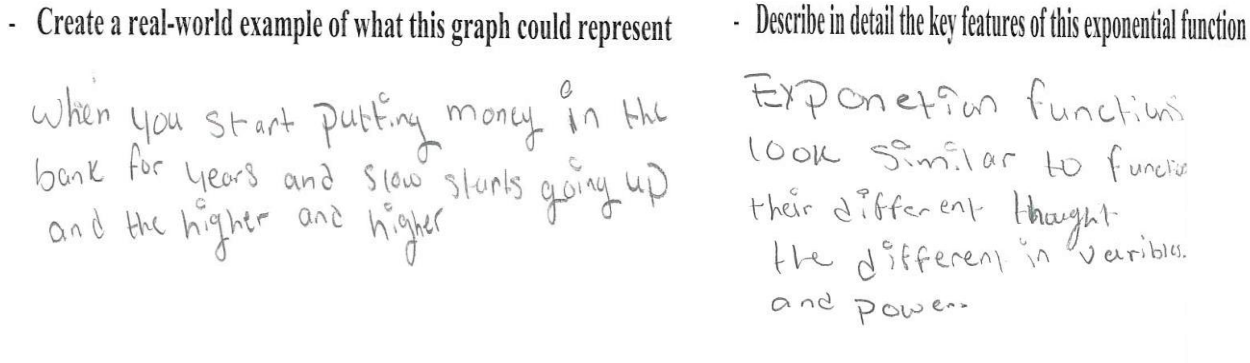
Figure 6. R.D. (a) and S.H. (b) used their written contract to create a table and graph the loan payment data.

This concept journal writing activity provided the students the opportunity to further construct meaning by relating linear functions to loan payment. The students extended their associations of linear functions with the learned experiences of purchasing/selling an automobile and writing a contract. In turn, the students were able to graph and create a table as alternative means to simulate payoff information for the car. In another instance, R.D.'s work presented in Figure 5 provides evidence of how the students were able to develop a contract and payment plan for selling an automobile. This activity was relevant as many of the students in this Coordinate Algebra class had previously experienced purchasing an automobile (for themselves or with family) or would soon be purchasing an automobile.

Notice the discrepancy in students' depiction of the direction of relationship. For example, R.D. graph, presented in Figure 6(a), shows a decrease in the direction of pay off while S.H. graph, presented in Figure 6(b), depicts an increase. After discussing the rationale behind choosing these directions, R.D stated his "goal is to be debt free and have a balance of $0." And,

S.H. wanted the graph to represent "the amount earned in order to pay off the debt." As Hassett (2010) suggested that "the activity of constructing meaning necessarily relies on the social and cultural resources avail (semiotic modes) both in the text and in the classroom" (p. 92), this particular discussion allowed the students the opportunity to construct mathematical understanding of what it means to be financially responsible (paying off debt versus amount of money earned) and to prompt their prior knowledge to resolve problems addressed in the concept journal writing activity.

In another account, Figure 7(a) and Figure 7(b) provide evidence of how students *interpreted* the exponential graph (Figure 8) to correlate with a real-world example and *described* key features of an exponential function.



a. b.

Figure 7. R.S. created a real-world example of what the graph in Figure 8 could represent (a) and he described the key features of an exponential function (b).

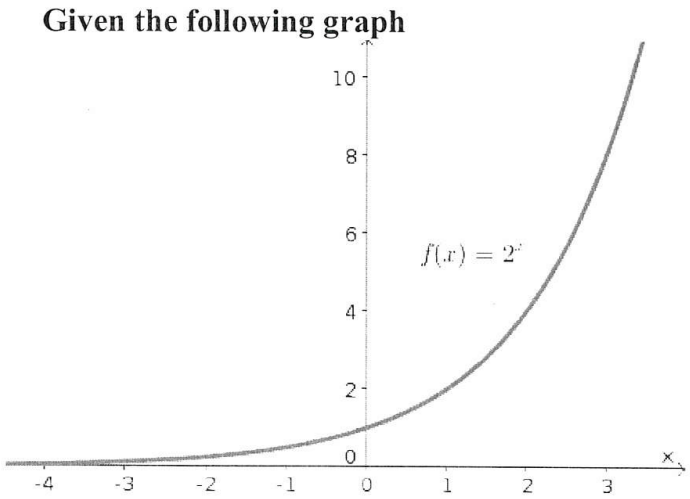


Figure 8. Graph provided from the writing activity regarding exponential functions. Students used this graph to answer questions shown in Figure 7.

At the beginning of this concept journal activity, the students made it clear that they had little to no experiences with exponential functions prior to the lesson that was presented. Svensson et al. (2009) argue that "learning is to a large extend depend on previous learning" (p. 222). From this exchange of lack of understanding, I asked the class "Is there an image that you can think of that looks similar to this graph?". T.S. spoke up and addressed the class, "Remember last week in Biology when we discussed the bacteria growth and decay and looked at the slides. This is like the same." Then she paused. This interjection evoked images thus allowing students to understand that "meanings are not fixed but fluid and situational, created by readers who draw on their prior experiences, ask questions, and make predictions to comprehend" (Maine, 2013, p. 151).When T.S. utilized her prior knowledge it allowed the other students to make meaning of the new situation by relating it to a prior real-world classroom experience hereby building on associates of ideas of exponential functions in terms of graphs and equations. From this oral dialogue and through the process of concept journaling, students were able to expand their understanding of exponential functions. To illustrate and as shown in Figure 7, R.S. was able to

translate the graph into a textual real-world example and further employ his prior knowledge to explain and interpret the major features of exponential functions.

Another example, in Figures 9, 10, 11, and 12 presents evidence of how students were able to *represent* each variable of the compound interest formula, *appraise* offers from banks for certificate of deposits (CD), *compare* rates, and *justify* why they would deposit money in a particular bank.

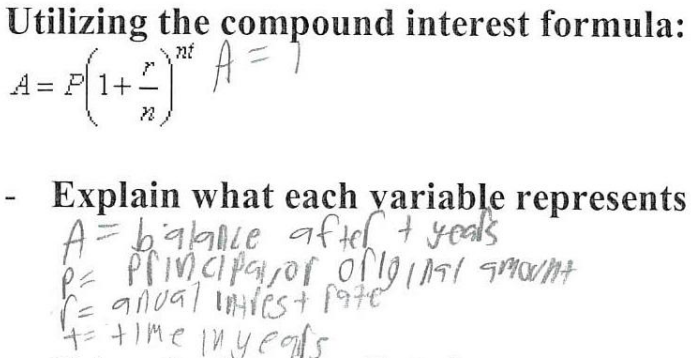


Figure 9. R.C. explained what each variable represented in the compound interest formula.

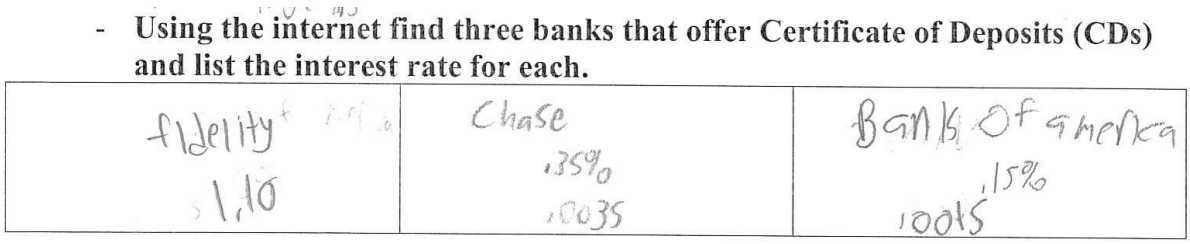


Figure 10. R.C. used the internet to find three banks' interest rates on certificate of deposits.

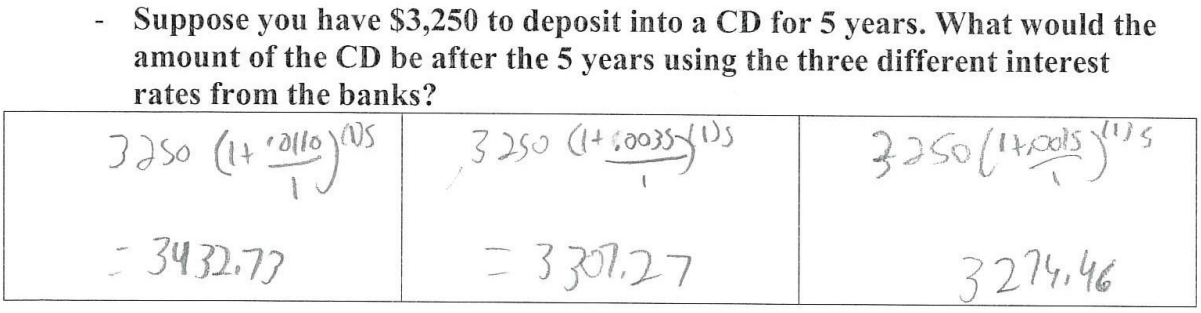


Figure 11. R.C. used the given scenario and interest rates in Figure 10 to calculate the balance of the certificate of deposit.

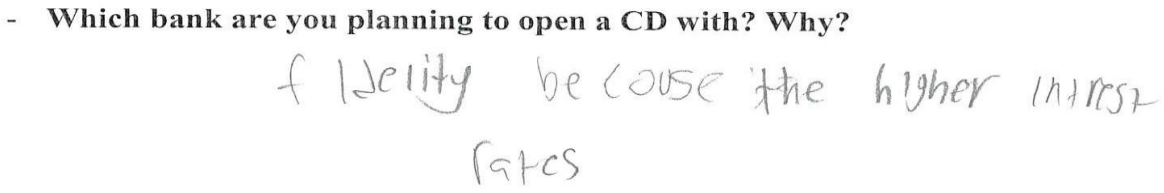


Figure 12. R.C. justified why he would deposit money in a particular bank using the calculated amounts from Figure 11.

Students took immediate interest in this concept journal writing activity because several of them suggested to the class they were saving money for "college", to purchase "a car", or "new shoes." The students were able to build off their prior knowledge of formulas to understand what each variable represented in the compound interest formula. Next, students relied on their prior knowledge to list three different banks and as they were accessing the internet to research the banks' interest rates, I posed the question, "Why did you pick the three banks you selected?". R.S. responded, "My parents bank with two of these banks and I just selected the third one because I see it every day on the way to school." And T.S. said, "Yes, everyone knows of at least three different banks." This exchange supported the notion that students bring prior experiences into the learning environment.

Moving through the writing activity, the next section required students to apply the compound interest formula utilizing the rates. McLeman (2012) asserts that students "need to know not just mathematical terms but what the terms mean and how they should be applied in different context" (p. 33) in order to enhance their learning by building association of ideas through multiple domains (i.e. through basic mathematics to mathematics application using banking). As a result of concept journaling, students were able to understand and apply their knowledge of the compound interest formula through calculating an investment, making a decision about which bank they would deposit the money in, and justifying their selection.

In addition, many of these students currently have a job and are saving to buy something, (e.g. college, automobile, new shoes) and the students stated that through this assignment they became more aware of the process of investing money. It is obvious that when the students were asked what bank they planned to open a certificate of deposit with, they all concurred with the bank that returned the greatest amount of money based on the investment. But, in addition, M.R. (Figure 13) explained that he selected Delta Community Credit Union because he already had a relationship with that bank. Maine (2013) encourages teachers to recognize that students "bring with them their own experiences, expectations and motivations, which affect the meaning that is constructed" (p. 151). Examining M.R.'s written response made it easier to discern a correlation between prior experiences and improved learning.

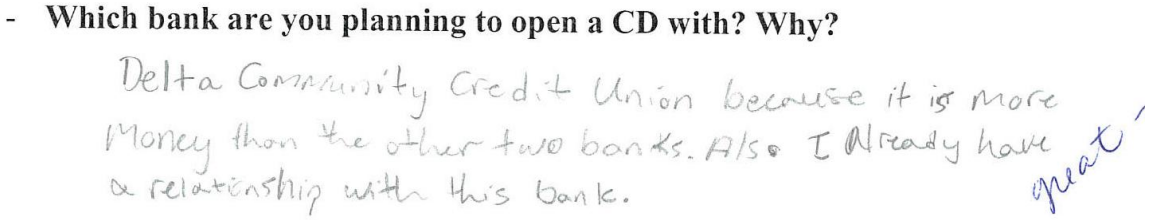


Figure 13. M.R. justified why he would deposit money in a particular bank using his calculated amounts.

In a separate activity, Figure 14 provides evidence of how students *compared* and *contrasted* linear and exponential functions on a Venn diagram.

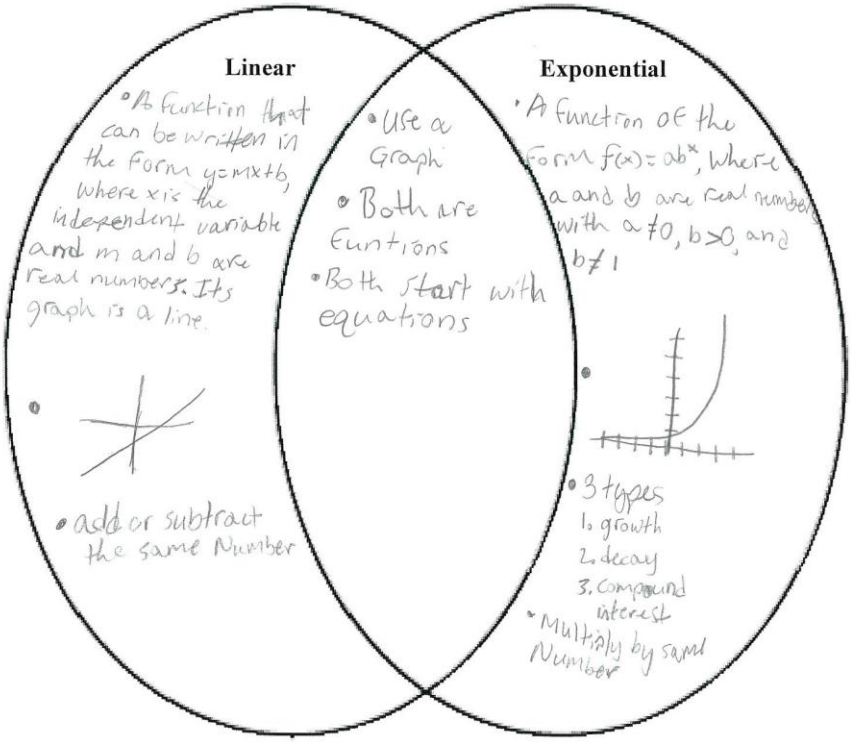


Figure 14. M.R. identified the commonalities and differences between linear and exponential functions using a Venn diagram.

The writing activity provided students the opportunity to validate their understanding of linear and exponential functions using Venn diagram. For example Figure 14 shows that M.R. utilized his prior knowledge in order to understand the similarities and differences between linear and exponential functions. Sevensson et al. (2009) describe this type of learning as a "character of learning, [because] it involved the creation of a unique act on the basis of previous experiences and the specific character of the present situation" (p. 221). Therefore, concept journaling facilitated the process of building meaning of functions from previously learned experiences beyond what they encountered in the Coordinate Algebra classroom.

In another depiction, Figure 15 and Figure 16 show how students located and *interpreted* real-world images using linear and exponential graphs, *described* features, and *compared* and *contrasted* linear and exponential functions.

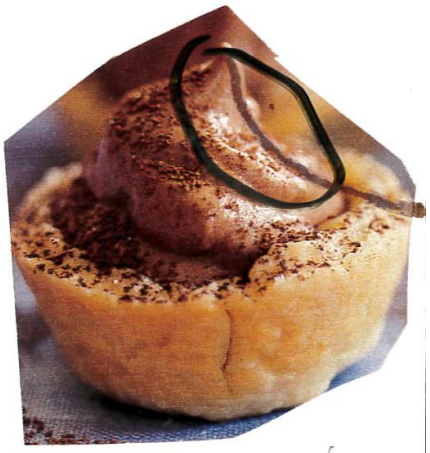
	Linear	Exponential
Cut out and paste each example		
Identify and describe the key features of each linear function image and exponential function image	the shadow makes a straight line	the icing curves so it's exponential

Figure 15. R.C. used linear and exponential graphs to model real-life images and described features of the functions.

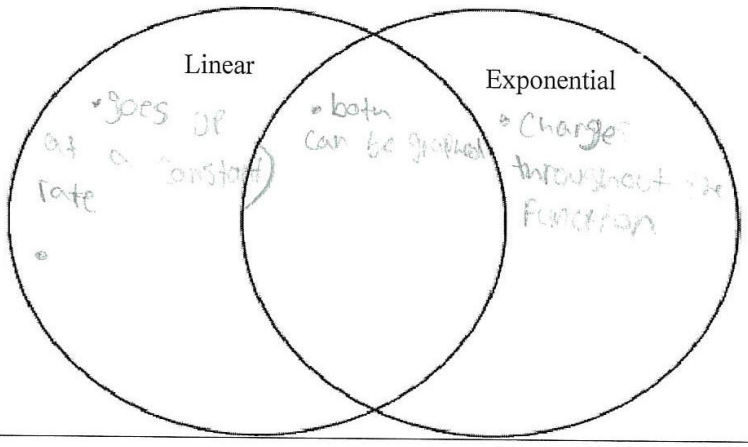
Compare and contrast the linear function image and the exponential function image	

Figure 16. C.M. used his real-life images to compare and contrast linear and exponential functions.

This writing activity required basic understanding of linear and exponential functions. To solve this problem, students are expected to employ higher-order cognitive processes to

access prerequisite concepts from “mind-wherein the long-term memory is found” (Birjandi & Sabah, 2012, p. 62). This concept journal allowed the students the opportunity to deepen their understanding of functions using real-world situations in conjunction with prior experiences to write their solutions to the problems activity. The written descriptions of the images provided a way for communal meaning to be portrayed in ordinary language to show understanding of the functions (Horwich, 2006). Figure 15 and Figure 16 support how the students used images from magazines to further build associations by modeling real-life phenomena using linear and exponential functions hereby identifying, describing, and comparing and contrasting underlying ideas in a narrative form.

Theme 2: Concept journaling created a space for negotiating meaningful connections using multiple resources. The first concept journal was a starting point of activities that provided a visual text that allowed for “scaffolding support for the instructional use of multimodal resources” (Hassett, 2010, p. 95). The students were able to use multiple resources to further construct meaning from the lesson taught on linear equations (x/y table, graphing, and features of linear functions). For example, as two students were working together to locate answers in their notebook, (Figure 17) I asked them, “What are you looking for?”. M.R. responded, “We know the answers are right, we just want to check through the vocabulary to make sure we did not miss a key feature.” Through this interaction it was apparent that the concept journal writing activity provided the opportunity for the students to draw on artifacts to further create understanding of mathematics.

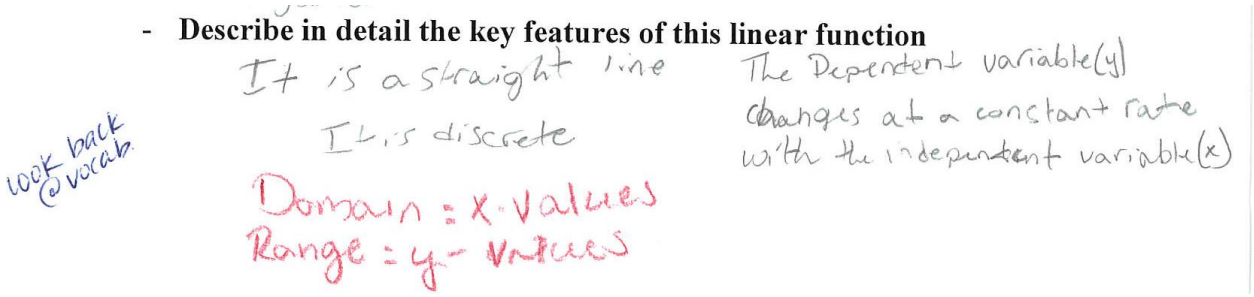


Figure 17. M.R. described the key features of a linear function.

In another concept journal activity, students created a contract for selling an automobile (Figure 18). Students researched the internet to assist them in broadening the components of a contract for selling an automobile. As two students were accessing Google, I asked, "What are you going to look up?", and S.H. replied, "Sales contract for a car." T.S. chimed in and stated, "My parents recently sold a car on Craigslist and my mom used a PDF that she found from a Google search. I am going to try to find that PDF." Through the use of the internet students triangulated multiple sources of information to relate the writing activity beyond the actual mathematics presented and therefore, broadened their overall learning.

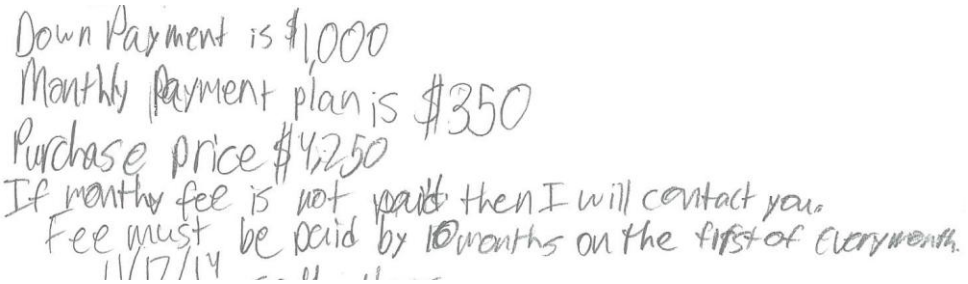


Figure 18. S.H. wrote a contract for selling an automobile based on information provided in the writing activity.

In another account, and as I observed students employing multiple representations of exponential graphs similar (Figure 19), I noticed that two students had multiple windows open from various websites to compare information on exponential graphs. I asked these two students "Why do you have multiple web browsers open?", and R.S. replied, "I want to compare the information from each website before I write it down." Then S.H. explained, "Most of time the

websites will have the same information just written a little different. Sometimes it is easier to understand one better than the other." As the students were negotiating the use of multiple resources, they utilized pictorial images as a meaning-making tool to create new meaning (Hassett, 2010). When students are given the opportunity to use multiple resources, they are able to construct meaning through reflecting on the text given.

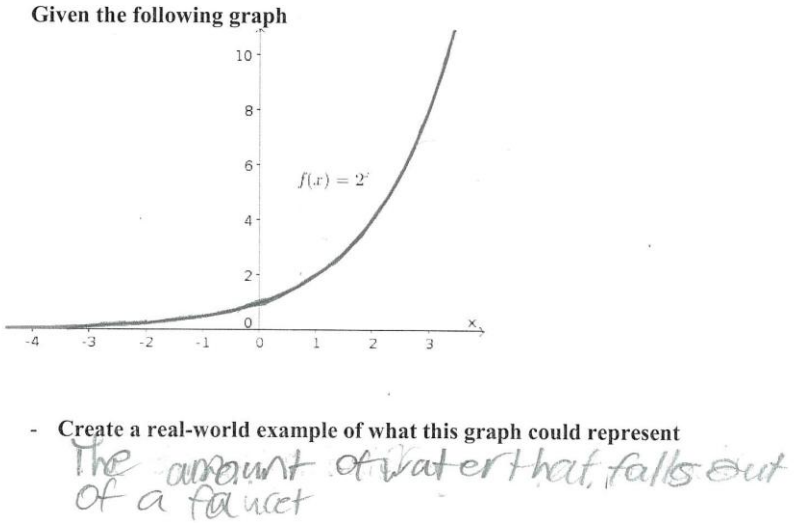


Figure 19. S.H. used the exponential graph provided to create a real-world example of what this graph could represent.

In an additional example, as the students were accessing the various banks' websites (to research the certificate of deposit rates), they quickly realized they would be required to read the interest rates on a chart. Students deciphered the chart provided based on the initial investment amount, the term of the investment, and interest rate to successfully respond to the concept journal writing activity. R.S. noted, "The more money you have to invest, the higher the interest rate, and the more money you get back, the longer the money is left in the bank." Translating information between and within multiple resources of data provided an unconventional way of reading and responding to text. Gavelek and Bresnahan (2009) affirm "the construction of meaning from text – is one of the most important competencies that students can master" (p. 140) and "knowledge-able individuals must learn to read different texts in different ways for

different purposes and should be taught accordingly" (p. 152). Through concept journaling, students expanded their knowledge on how to compare and contrast artifacts as they resolve the problem encountered (Figure 20). The skill to translate within and between different types of texts is an important prerequisite of understanding problem solving as a process of making meaning of situations.

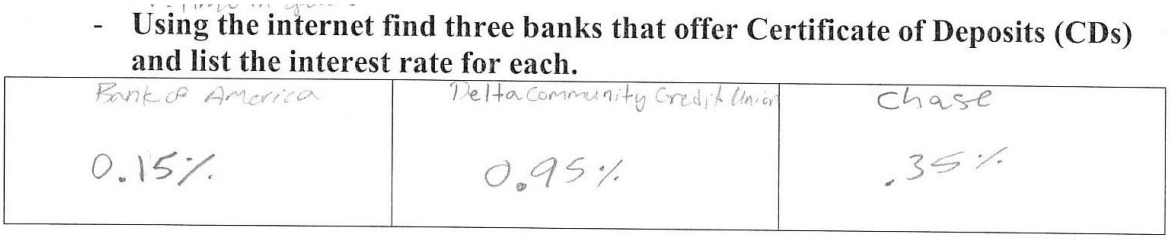


Figure 20. M.R. used the internet to find three banks' interest rates on certificate of deposits.

As an illustration, and in order to complete the Venn diagram (Figure 21), students used multiple objects including words, symbols, graphs, and equations to represent linear and exponential functions.

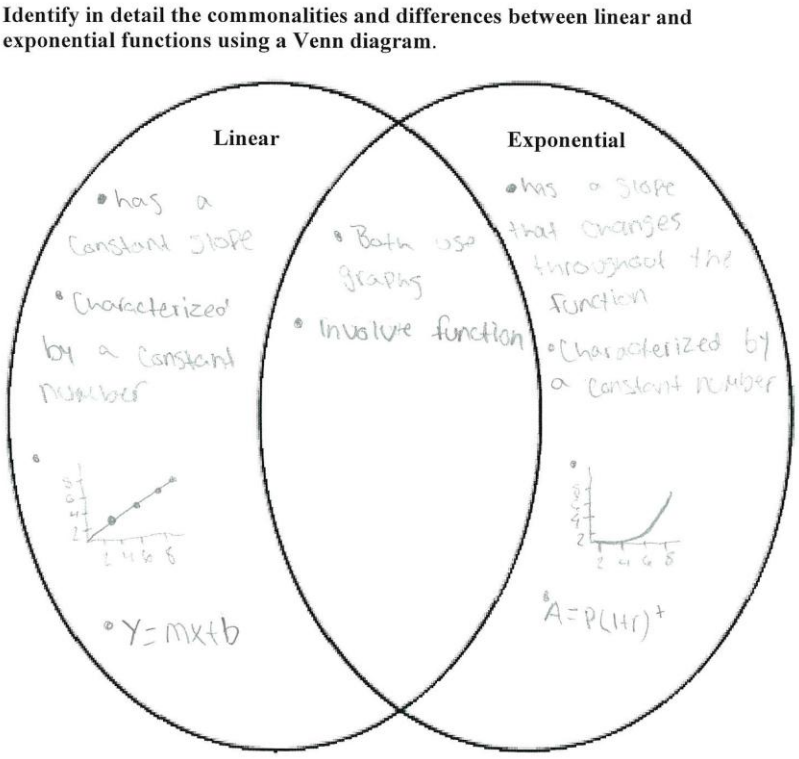


Figure 21. C.M. identified the commonalities and differences between linear and exponential functions using a Venn diagram.

A couple of students (which ended up with all of the students around one computer together) accessed YouTube to watch videos for additional information to add to the Venn diagram. Maine (2013) explains, "If we [educators] embrace pictures, films, digital forms and animations as texts from which meaning can be constructed, we can also extend the notion of text comprehension to support this meaning-making" (p. 150). Students were eager to watch the videos they found surrounding linear and exponential functions. As with the previous writing activities, students relied on textual resources to explain their understanding; however, using YouTube was the first time they employed videos to assist them in creating meaning. Gavelek and Bresnahan (2009) argue "computer-based, hypertext and hypermedia has transformed reading comprehension from a linear, symbol-based process tone that is both multidirectional and multimodal" (p. 146). I was

impressed with how well the students were able to decipher through the videos and select the essential information to complete the Venn diagram.

In another concept journal activity, students were selecting a printed resource (newspapers, sale ads, and/or magazines) of his/her choosing to identify a real-world image that can be modeled using linear and exponential graphs. Since I did not have a printer in my classroom, printing an image from the internet was not an available resource for this activity. As shown in Figure 22, students selected several pictures from magazines to include in their journals. I asked the students, "Why did you all not use the newspapers or sale ads?". R.C. responded, "It is easier to find pictures in magazines and you have magazines that are fun to look at." R.D. chimed in, "Yeah! Car magazines, National Geographic, sporting magazines…the newspaper and sale ads are not as fun to look through." Students located a magazine that they took interest in to select the images for the activity. Many of the images selected to represent a mathematical concept were meaningfully relevant to students' interests. These images represented spaces where "open, suggestive and negotiable, meaning that different interpretations or priorities for discussion were possible" (Maine, 2013, p. 154). After each image was selected, it was obvious that students were able to identify, describe, and compare and contrast major characteristics of linear and exponential graphs building on their prior knowledge and understanding of functions.

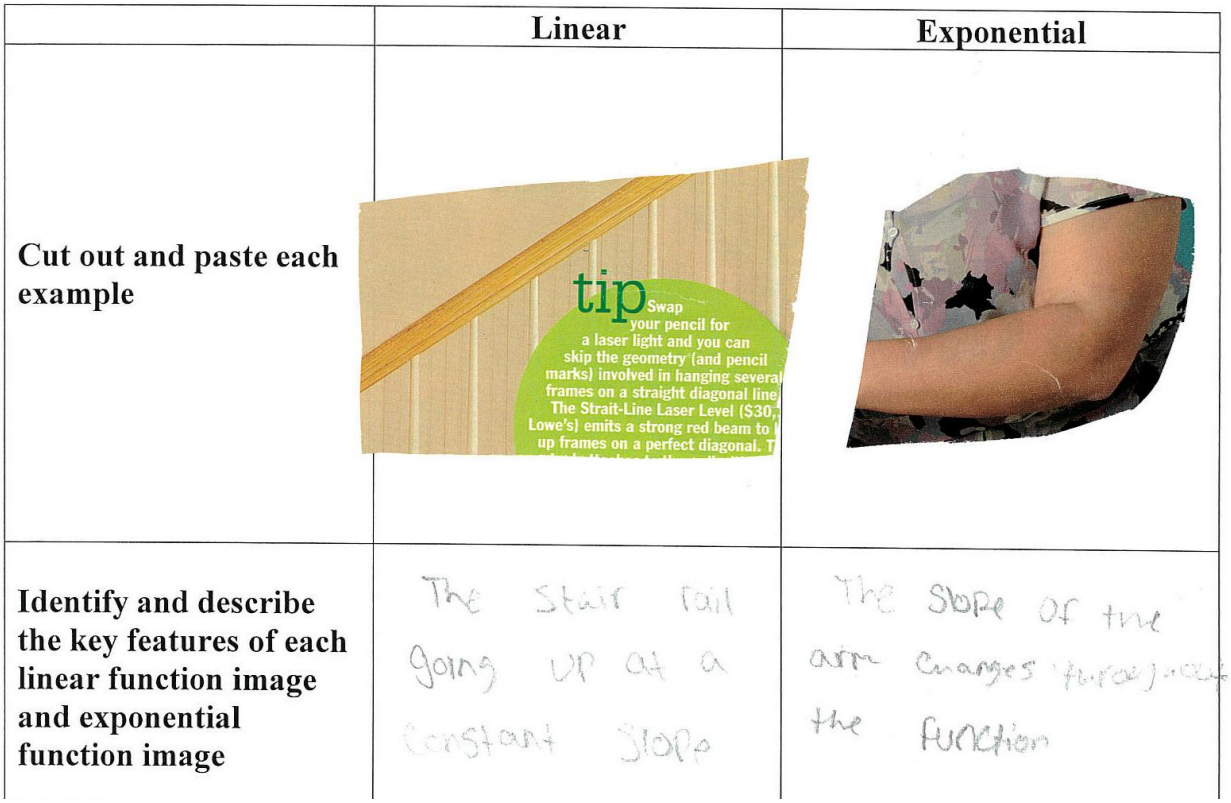


Figure 22. C.M. used linear and exponential graphs to model real-life images and described features of the functions.

Theme 3: Concept journaling provided opportunities for constructing meaning in context via peer communications and exchanges of personal views and ideas. Students were very attentive while the directions were read aloud for the first writing activity. After I finished reading, R.D. asked me if he "could graph the data before he gave the real-world example", I responded with "Sure, but why?", and he said, "It is easier for me to give an example once I see what the numbers mean on the graph." I noticed that many students did graph the data before creating a real-world example (Figure 23 and Figure 24). It was apparent that students had an understanding of the meanings of mathematical terms and statements and were able to interconnect all the terms in the x/y table, in the graph, and in turn to a real-world example. For example, when C.M. asked, "Could this be a discrete graph?", R.S. quickly and simply replied, "Yes, if your real-world example was counted in whole units." And then students returned to

working. Through this interaction between R.S. and C.M. possibly all meanings related to different types of graphs shifted to a higher level of understanding.

Given the following table

x	1	2	3	4
y	5	10	15	20

- **Create a real-world example of what this data could represent**

For every person that get on the bus, the busdriver gets 5 dollars.

Figure 23. R.D created a real-world example of what the data could represent that was provided in the table.

- **Graph the data**

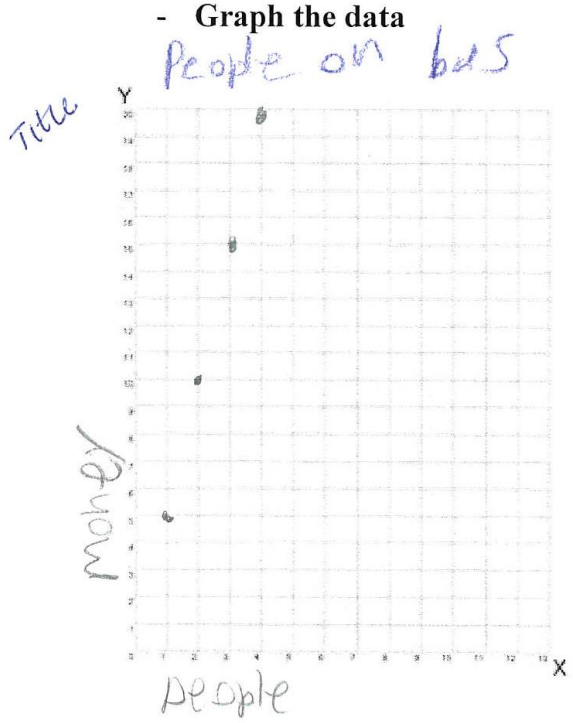


Figure 24. R.D. used the data provided and real-world example created in Figure 23 to illustrate on a graph.

For the next writing activity, the students verbally collaborated together through a class discussion to make a list of the basic components of a contract. As the students were using multiple representations of a contract (i.e., PDF, websites, prior knowledge, etc.), they were just shouting out different parts of a contract when R.S. suggested that he would write a list on the board. R.S. "assumed the role of teacher and [was] able to engage in dialogic interaction" to further assist his peers in making meaning (Gavelek & Bresnahan, 2009, p. 256). Together, the students were able to come up with the following components of a contract: date, purchase price, amount to pay each month, date when payments start and end, what happens if you do not pay, and signatures of both parties. As the students began to work on writing the contract, they were discussing what happens to the original loan value when a down payment is applied when purchasing an automobile (Figure 25). S.H. suggested that, "If I have $500 to put toward the purchase price, the loan amount decreases to $3750 and therefore, the table and graph would be affected." R.D. recalled purchasing his first car, "I just purchased a used car and needed $1,000 down." As a result of these discussions, students were able to construct meaning by exchanging experiences and ideas while in the mathematics classroom in a dialogue with their peers.

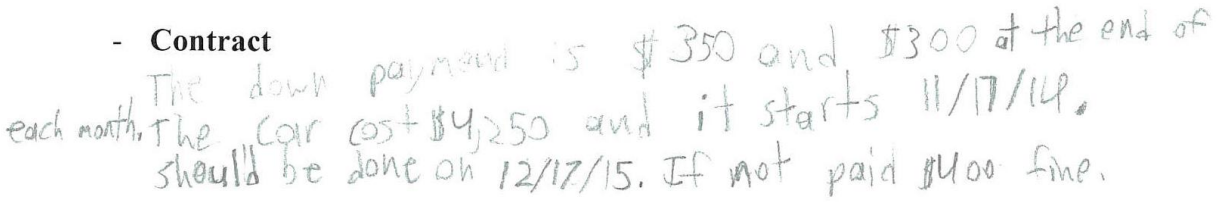
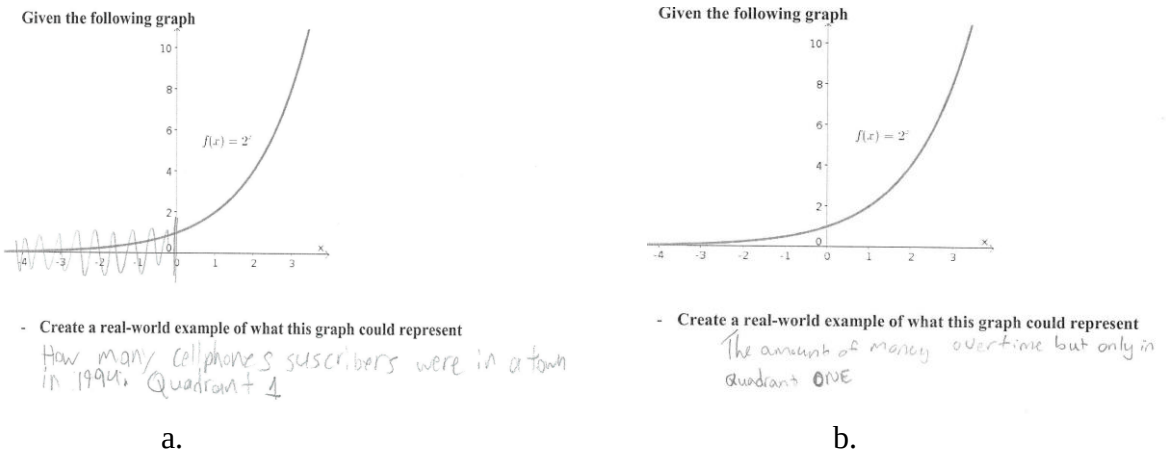


Figure 25. R.D wrote a contract for selling an automobile based on information provided in the writing activity.

It was interesting to note that students were continuously engaged in oral discussions as they were writing their journals. When I asked the students "Why do you all talk during the concept journal writing time?", R.D. replied, "We are able to discuss our questions and read the answers." As the students were conversing, it furthered the idea that "meaning is an essentially

social phenomenon" (Horwich, 2006, p. 50). The students were able to utilize the time allotted to further negotiate meaning through peer communication while in the social environment of the classroom. In addition, I noticed that these two students (Figure 26) only wanted to use the Quadrant I for the graph. A discussion with each other followed:

R.D.: I am going to cross out the second quadrant.
M.R.: Why?
R.D.: You cannot have a negative number of people with cell phones.
M.R.: Makes sense!



a. b.

Figure 26. R.D. (a) and M.R. (b) used the exponential graph provided to create a real-world example of what this graph could represent.

From this conversation, the language used by R.D. became central to understanding learning for M.R. Obviously, the brief exchange between the two students influenced M.R.'s answer because his written response for the real-world example implied "only for Quadrant I," as shown in Figure 26(b). As Birjandi and Sabah (2012) suggest, "the activity of thinking takes on a particular quality when it is employed in the activity of speaking" (p. 64). Concept journaling made it possible for students to create meaning of the concepts and to use different types of representations to express their thought processes.

During another concept journal, when students realized that bank interest rates varied on initial investment and term length (Figure 27), a class discussion was initiated after C.M. stated that, “With the current economy and the housing market down, the rates would be lower.”

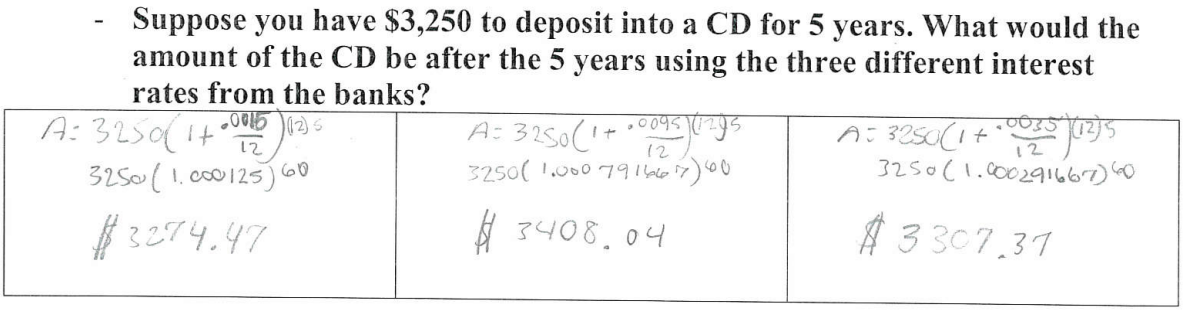


Figure 27. M.R. used banks' interest rates and the given scenario to calculate the balance of the certificate of deposit.

I encouraged the students to think out loud as they were engaged in discussions on the current state of the economy. Smith (2010) argues that effective learning can be achieved by encouraging the children to make meaning together. For example, R.D. stated, “The housing market is not as bad as it was a couple of years ago.” S.H. suggested that he “heard on the news there were not as many foreclosures lately.” I posed the question, “Do you think that the number of foreclosures affects the interest rates on CDs?” and then a brief pause of silence followed. Maine (2013) explains that this type of silence is “where meaning is constructed and re-constructed in the gaps between speech and response…an opportunity for questioning and exploration rather than singular, correct or closed response” (p. 151). After several moments, students started to respond sporadically as they were thinking during the silence. This reminded me of the statement that “language is considered as the mirror of the mind” (Birjandi & Sabah, 2012, p. 59).

During concept journaling and as students were engaged in discussions, several significant ideas emerged. R.D. made the connection between banking and financing a home by

explaining, “Banks lend money for people to finance a house and if a lot of houses are foreclosed on the banks could lose money.” R.S. added, “And if the banks lose money from foreclosures, the less money they will be able to give for investments.” Through these classroom interactions, students were “connecting the referential notions with that of meaning in language” from using the exchange of personal views and ideas to reference mathematics (Higginbotham, 2006, p. 61).

When discussing different elements of functions as they completed the Venn diagram (Figure 28), students made explicit statements to make meaning of major ideas in linear and exponential functions : “linear is a straight line and exponential is a curved line”, “linear is constant”, and “each can be represented by a graph and a function.”

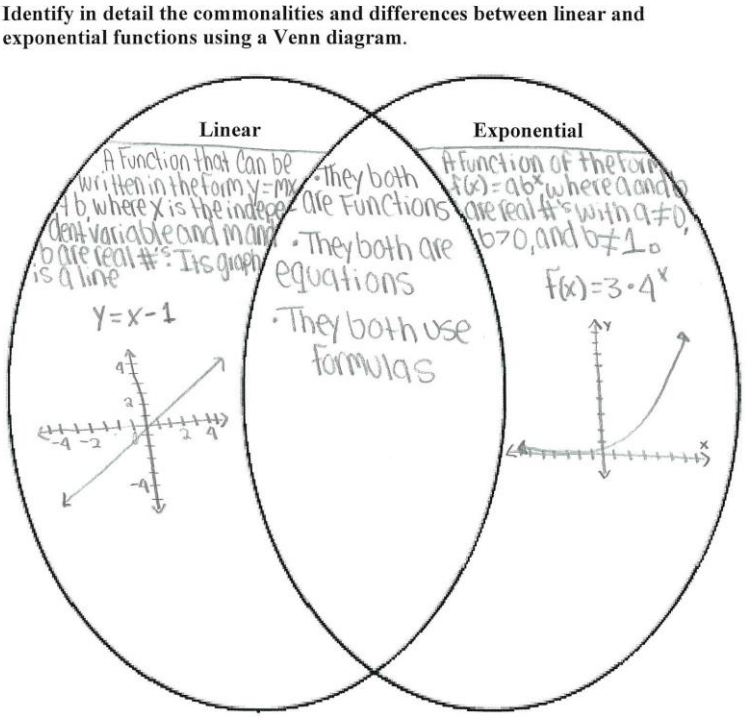


Figure 28. T.S. identified the commonalities and differences between linear and exponential functions using a Venn diagram.

Also, T.S. used her index finger in the air to motion what a linear line looked like and then she did the same thing to show a basic exponential function curve. This action confirms Hassett’s (2010) claim that, “their [the students] resources for making meaning include talk, gesture,

drama, drawing, and ways of incorporating, integrating, and extending linguistic signs" (p. 91). Students were able to center their learning around the use of nonverbal and verbal language to further construct their own learning and understanding of the mathematics presented (Svensson et al., 2009).

Moreover, when students cut images from magazines to complete the final concept journal, they were also assisting each other with finding the pictures and discussing the shape of each graph (Figure 29).

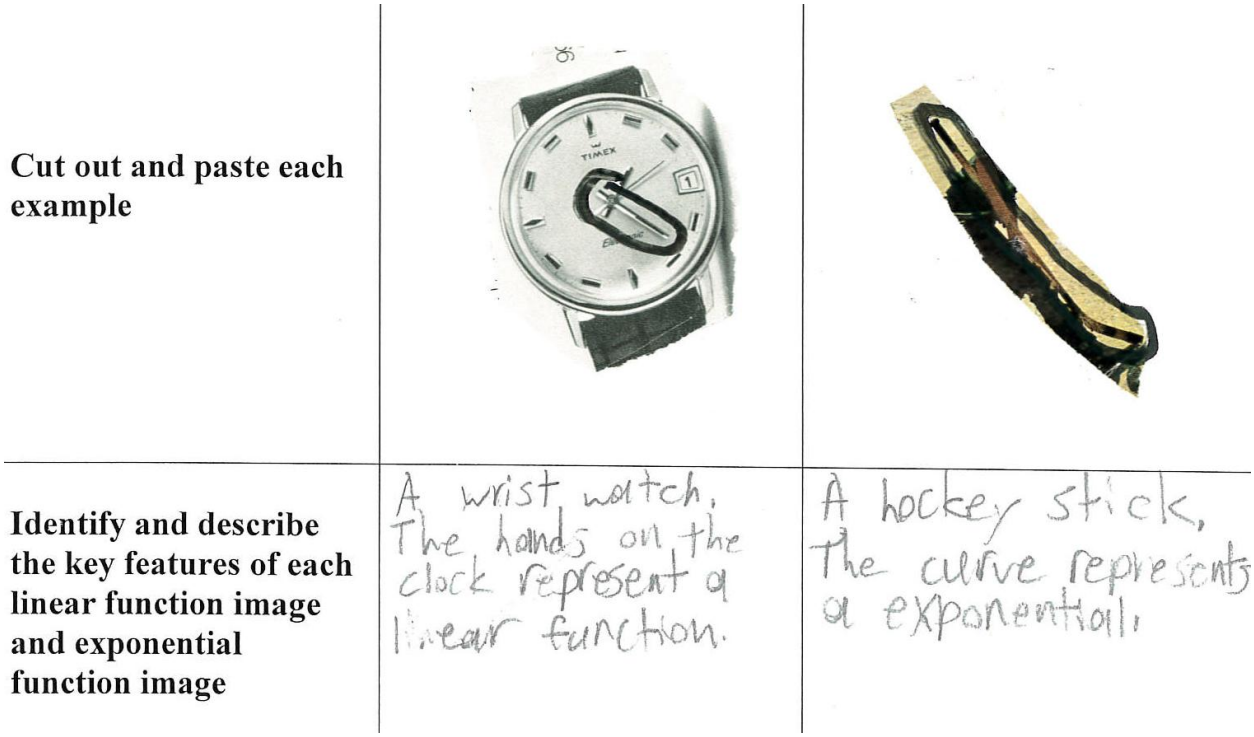


Figure 29. R.D. used linear and exponential graphs to model real-life images and described features of the function.

The peer conversations overheard are as follows: "just find something with a straight line for a linear and a steep curve for exponential" and "if you can justify your picture with your answer, you're good." This observation aligns with Wegerif (2011) findings that "successful groups seemed to be listening to each other, asking each other for help and changing their minds as a result of seeing the problem as if through the eyes of others" (p. 180). Also, S.H. pointed to

R.D.'s cut out image of a watch (Figure 29) and inquired "How does that make a line?" and R.D. responded "The watch hands are a straight line." For the duration of this concept journal writing activity, students were "meaning making in a collaborative way, each building on the others' contribution" (Taylor, 2012, p. 163).

Student Perceptions

Student Perceptions

For the duration of this study, there were many occasions when I as the researcher/teacher, used my introspection in order to make inferences to students' potential perceptions. During the course of the study, students had a difficult time verbally communicating how they perceived learning. In addition, many of these students would express their learning using simple and quick responses. Yet, when students were given the opportunity to reflect on their responses, they confirmed an understanding of how concept journaling provided the opportunity to connect mathematics to the real-world and how they became self-aware of learning and social space.

Theme 4: Students saw concept journaling as a meaningful experience to further their understanding of mathematics using real-world applications. NCTM (2000) recommends that students should be able to make connections, to recognize, and to apply mathematical topics outside of the mathematics field and in real-world contexts. During the pre-interviews, it was noted that after students were aware of their prior knowledge, they were then able to relate their understating of reading and writing from their previous real-world experiences. When I asked, "Do you read?", students responded quickly with, "No!". Then there was a short pause before R.S. wondered if I meant reading to include, "Anything?". The question posed by R.S. allowed other students to further engage in extended dialogues. As they were

exchanging ideas, students realized that they actually read and wrote all the time: "texting," "reading a menu," "going into a store," "applications," "when given instructions," and "advertisements." Hassett (2010) confirms that students use various modalities in learning and they just have to become aware of when and where reading and writing is present in order to understand how to make meanings in additional ways. This suggests that when a student is able to connect prior knowledge, real-world experiences, and language skills, he/she is able to further make meaning of mathematics.

A significant outcome of concept journaling was that students were able to translate within and between different types of graphs, charts, mathematical formulas, diagrams, and/or images of real-world situations. Therefore, students used textual narratives inspired by real-life contexts to explain mathematical language to further understand mathematics. Svensson et al. (2009) recognized that "understanding and knowledge as a prerequisite, process and outcome of learning, is also seen as a relation between the individual and the surrounding world" (p. 210). The informal discussions that occurred for the duration of the study provided evidence of how concept journaling uncovered student understanding of mathematics in the context of real-world experiences.

For example, when I asked, "Where do you get your answers?", T.S. indicated that she "knew most of the contract because her mom just sold her car," and when R.C. was asked "What is unique about the concept journals?", he pointed out that through the writing activities he could apply it to "something other than just math – something I could use in my life." In addition I asked, "How has this kind of writing helped you learn math?", R.D. explained that he uses the "internet to find out about the real-world," and M.R. attests that this type of writing had him "thinking and searching for an answer that is different" that required him to "look up banks,

selling the car, finding a graph, watching YouTube…" Students' responses supported Gavelek and Bresnahan's (2009) claim that the students "must see the world as refracted through the text as well as draw on their world-view. In doing so, the reader simultaneously connects their world view with the text – producing a new representation or expanded understanding" (p. 161). Students' voices confirm the fact that they found concept journaling as a meaningful experience to connect them with mathematics and in turn to connect mathematics to the real-world. Writing in concept journals afforded students the opportunity to learn by transitioning back-and-forth between different lived experiences whether in the classroom or in the real-world. As such, students became more proficient in understanding and connecting mathematics to their real-world experiences by exploring new ways to enact meaning by writing their concept journals.

As the study came to a close, students were able to respond promptly during the post-interview in regard to how the process of concept journaling afforded them the opportunity to strengthen their understanding of mathematics. For example, when the students were asked to describe what a concept journal is, R.S. described concept journaling as "Writing in math." In addition, C.M. described a concept journal as the opportunity for "using real-world examples for math." When the students were asked to provide specific examples of where real-world experiences were used in the concept journal writing activities, in unison the class suggested "banking." And then several students continued to elaborate by mentioning several topics such as: "traffic and cars;" "cell phone [usage];" "interest rates;" and "cars and a loan." Hassett (2010) makes the case that, "With each new reading and writing activity a new meaning may be produced" (p. 96). With each new concept journal, students were able to construct new meanings and make connections between mathematics and the real-world. Dombey (2013) contends that as educators "we can help them [students] take possession of the written word and use it to make

sense of their lives, and the world around them" (p. 35). The concept journaling process assisted students to incorporate writing to construct meaningful learning.

Theme 5: Concept journaling was viewed by students as a medium to develop an awareness of the self while immersed in meaning making contexts. Common Core State Standards for Mathematics (2010) suggest that it is essential for students to "make sense of problems and persevere in solving them" (p. 6). Further exploring this viewpoint, a student of mathematics should be conscious of his/her knowledge and learning and aware of his/her social space within the classroom setting. When learning mathematics, I argue, a student must have a basic awareness of his/her knowledge before a question can be posed regarding either a misunderstanding or to further his/her understanding. By the same token, when a student is responding to a question, he/she must be conscious of his/her knowledge before an answer can be composed in thought and then translated into a response. This same notion of self-awareness extends to an awareness within a social space situated in a classroom setting. During the pre-interview when students were asked to express how writing and overall learning are linked, there was great hesitation from students in answering the questions. While students did demonstrate an awareness of how writing is used as a tool for learning, there was little emphasis on how this tool could be utilized in mathematics. Furthermore, it was noted from the pre-interview that students appeared to have a simplistic understanding of writing and a very basic connection between what it meant to learn mathematics through writing. Yet, students did make the connection that reading makes "better writers" and agreed that it is easier to "learn/remember if you write something down."

From the observations and the informal discussions that occurred during the study, it appeared that students took the opportunity to become more self-aware of their learning by

reflecting on their thinking and by organizing their thoughts before the writing began and as they wrote. Students' initial engagement with concept journaling and after reading aloud the prompts in the first concept journal that students are expected to write, many of the students waited for additional guidelines in order to proceed. When students realized that there were no additional instructions they started questioning: “This is the x-value, right?”, “And we graph this on the horizontal line, right?”, “I can use any real-world example?”, “What are some of the key features you want?”. And I simply replied each time with, “Look at your notes, ask your peers, use the resources –.” From this concept journal forward, students rarely directed any of their questions to me, instead they would ask their peers, look through their notes, and/or use the internet to locate a resource to write in their concept journals. Also, some students would sit in silence, without the directive from me, for a few moments after the prompt was read aloud. During this time, students wrote down what they already knew or could easily access in their notebook. Someone would always break the silence of the class and then the students would move to sit in groups surrounded by the resources (sometimes as a whole class) and discuss and respond to the concept journal writing activity. When the students were asked, "Where did you get the answers from?" students replied that they "just know some of the answers."

Smith (2010) confirms that students are able to construct meaning by applying what they know inside a learning environment when their "established comprehension is the dynamic and continuous process of thought" (p. 66). Furthermore, when students were asked to voice their perceptions regarding the ways in which writing help them learn mathematics, S.H. explained, "If I write it down I learn it and remember it." Similarly, R.D. noted "Writing makes me think about what I know". Also, C.M. proposed, "It is harder to write down what I have to then just tell you. I have to really know what I am going to write down." As such, it was evident that students

were lucid in regard to making meaning of mathematics using concept journaling. Moreover, and from observing the several conversations in the classroom, it was obvious that students became more confident in their ability to respond to the concept journal writing activities because they wrote texts to further create meaning by becoming more self-aware of their own thoughts when composing a written response.

Furthermore, students became more actively engaged in the Coordinate Algebra classroom when they used concept journaling. Svensson et al. (2009) describe a learning environment where “parts of the environment individuals are interacting with in a way leading to learning” (p. 220) and “how good this learning environment is will also depend on the individuals’ way of interacting with it” (p. 220). From the several informal discussions, it was noted how students became more socially connected to the learning environment. For example, when the students were asked, "Where do you get the answers?", M.R. explained that he can "ask someone to help," if he does not know the answers. And when asked, "How are concept journals unique?", he responded, "[we] don't have to be silent when we are doing our work. We can talk about our answers." Being able to work with someone in a social setting was echoed throughout the discussions. For example, when the question was posed, "What is it about this kind of writing that helped you learn?", R.D. he is "able to work with someone." At a later time, when I asked, "How do you know your written answers are correct before you turn it in?", R.S. pointed out that "[we] are all talking about what we already know" and M.R. confirms that he and another student "read each other's answers" in order to make sure their written responses to the concept journals are correct. Hirsch (2010) proclaims that "we need others even to make sense of ourselves" (p. 216) and students' voices confirmed the fact that they were relying on connecting with their peers

in a social environment in order to facilitate their learning as they complete the concept journal writing activities.

In several instances of the study, I noted that when a student is asked to write, they often tend to hesitate at first. I attribute this hesitation to two facts: (1) students do not understand how to put thoughts into words, and/or (2) students believe that writing is a time consuming process. However, at students became more engaged in concept journaling, they became less frustrated as they found purposiveness and usefulness. As one student explained, "this [concept journaling] is quick. I feel like I am able to review the math."

In the post-interviews, students voiced an understanding of why writing is essential in mathematics. Students came to understand that writing can foster greater meaning. For example, when the students were asked, "Explain your opinion of concept journals and how they help you learn?", C.M. responded that concept journals "are more work but it is easier to understand and catch on fast," and R.S. added "you learn better" through employing writing in mathematics. Furthermore, R.C. was aware of the fact that concept journals "make you think in a different way." Dombey (2013) reiterates that "only through writing can they [students] learn to work out those ideas and reflection on those experiences in ways that carry their thinking forward" (p. 22). Through the process of concept journaling, students became more self-aware and articulated their thoughts using several modes of representations as they learned mathematics through writing.

In the post-interviews, it was clear that students were in sync with each other as they participated in the interviews, more so than the pre-interviews. Students were able to appropriately negotiate their spaces within the post-interview: they were eager to support each others' answers, they offered additional answers or opinions if needed and they appeared to be

more socially connected to each other. Maine (2013) explains, “Establishing a social cohesion through the common ground of agreement allowed the children to play with ideas and make suggestions for meaning” (p. 154). The social connections that were established during the concept journaling process afforded students the opportunity to further create meaning of mathematics through language and thought. I witnessed students forming relationships with each other and exchange and share ideas to compose a written argument in response to the concept journal activity. Gavelek and Bresnahan (2009) argue, “the role of social interaction is considered of crucial importance in the development of comprehension” (p. 159) and “making meaning from text simply does not just happen – it occurs as a result of participation” (p. 156). As a result of being engaged in concept journaling, social connections and relationships were formed and maintained during the study and these relationships were the catalyst that leveraged the process of making meaning of the texts in each writing activity.

Theme 6: Students expressed a sense of connection to mathematics through the use of concept journaling writing activities. NCTM (2000) recommends that students should be able to make connections and recognize mathematical topics, interconnect the mathematical topics to build on various topics, and apply mathematics to describe real world phenomenon. During pre-interviews, I noticed a general impression that writing can cross academic disciples (i.e. from English class to mathematics). For example, when the students were asked, "What is the purpose of writing in mathematics?", R.S. suggested that the only reason writing is used in mathematics is for “solving an equation.” I have witnessed this perceived notion several times in my algebra classes. Many high school students that I have encountered were previously enrolled in a mathematics class that utilized drill and practice to teach content and often the curriculum revolves around solving equations in Algebra. Freitas (2013) acknowledges that, “we need to

think mathematics out of the technical procedural tyranny of school mathematics, and inspire a resistance to the containment of such cultural capital" (p. 289). Writing is a way for mathematics to inspire this notion. S.H. is the only student that verbalized during the pre-interview that writing can be used in mathematics "to expand your knowledge on math" when he was asked "What is the purpose of writing in mathematics?". NCTM (2000) stresses the fact that the mathematics classrooms should connect the curriculum, instruction, and assessment together in order to provide the students with opportunities to understand the value of learning mathematics, to become confident in their mathematics ability, to communicate mathematics, and to reason mathematically. NCTM implies that there is one overachieving activity that can provide the occasion for students to make these connections in mathematics – writing. As (Dombey, 2013) explained, "Children need to know that writing is about communication and ideas" that provides them the opportunity to further make meaningful connections within the learning environment (p. 34).

As the students continued to use concept journaling to further construct meaning, their perceptions of learning shifted as they became more connected to mathematics. Students indicated that prior to concept journaling, they have not had the opportunity to learn or write in mathematics. For example, when the question was posed, "What do you think is unique about the concept journals?", R.C. pointed out, "This is a new way to learn math. It is different than the math in middle school" because through concept journaling they had "to write about something that we have learned and apply it." Svensson et al. (2009) contend that learning is dependent on the relationship between the individual student and the learning environment, and the context of learning involves both the experiences and activities that the individual student partakes while applying the knowledge. In this regard, the students were asked "Why is writing the responses

becoming easier for you?". T.S. recognized that she had to be connected to the mathematics taught in order to be able to write about it. She explained, “I know we are going to have to write about what we learned after each lesson. So I pay attention more when you are teaching.” Therefore, through writing and concept journaling, students were able to use “language as a means to understand mathematical knowledge” (McLeman, 2009, p. 28). Similarly, when the question was posed, "How has this type of writing helped you learn?", R.D. revealed that the concept journaling process has helped him learn, he stated, “I am able to review the math.” Svensson et al. (2009) acknowledges that the “most immediate context for learning is the activity itself” (p. 222). Concept journaling was the activity that students utilized to further construct meaning by establishing the connection between mathematics and writing.

The ability to learn is more powerful when a student is able to connect ideas to the subject matter being taught. It is an educator’s responsibility to create a learning environment and activities that allow students the opportunity to learn the subject matter through writing in order to connect ideas (Dombey, 2013). Dombey furthers this belief by suggesting, “learning to write is at the core of the education process” (p. 22), and if the learning environment, regardless of subject matter being taught, can revolve around writing, students will further create meaning through language and thought. In particular, when the students participated in concept journaling, they were able to utilize language and thought to encourage a connection between mathematics and other ideas. Even though the students voiced, during the post-interview, that writing in mathematics was “challenging” and “takes longer”, they still suggested “you learn faster, writing it out” and “you learn how to do it better.” For example, when the question was asked, "What is your opinion of the concept journals?", R.C. described writing in mathematics as an approach to make “you think in a different way.” This same sentiment was echoed when the

students were asked "Do you think that writing and overall learning are linked together?", as R.C. suggested, “If you write something down you can learn it faster.” Also, when students were asked, "How can writing in mathematics help you learn?", students responded that writing activities did help them learn by making “them think more and try more”, but you will have to “put more work into it.” Smith (2010) reminds educators that the classroom should be an environment “where good habits of thinking become the norm, [where] more children will be able to make more meaning from more and more text” (p. 71).

As I reflect on my observations, I can see how concept journaling assisted students in creating a learning environment that afforded students the chance to personally connect to mathematics through writing. Students were able to interact with mathematical concepts in an efficient way that helped in the retention of ideas. As Svensson et al. (2009) point out “knowledge is presented through language” (p. 208), thus when each student composed their written narratives, I could visually see different representations of student understanding and connections from the language and/or symbols they utilized in their written responses.

During the post interviews, many interesting statements emerged. For example, when the question was posed, "What do you think about the concept journals?", R.D. indicated that the writing is “basically more work” and “sometimes you don’t need it [writing] if you already understand it." Also, during the informal discussions, R.D. declared that he “does not like to write. But, this [concept journaling] is quick. I feel like I am able to review the math and I am able work with someone or use the internet to find out about the real-world.” He further expressed that writing helps him learn math because “writing makes [him] think about what [he] knows.” Furthermore, R.D.’s actions showed that he was active and responsive in the process of concept journaling. R.D. made contributions to the learning environment that allowed him to

further create meaning by connecting mathematics and writing and encouraged his peers to do the same.

Summary

As students engaged in concept journaling, several themes emerged that helped explain how concept journaling influenced student learning. As the students were prompted to engage in concept journal writing activities, students built on associations of ideas, negotiated meaningful connections using multiple resources, and maximized peer communication to construct meanings of mathematics. Data triangulated from multiple sources including interviews, casual conversations, and researcher's introspection provided insight into how the student perceived concept journaling as a tool for learning mathematics. The students indicated that concept journaling was a meaningful experience to further their understanding of mathematics using real-world application, made them more self-aware and socially connected to the learning process and to mathematics.

Through the process of concept journaling, students were able to further their learning by employing writing as a cognitive method to produce a written response to an open ended application problem. Simply stated by Chickering and Gamson (1987):

> Learning is not a spectator sport. Students do not learn much just by sitting in class listening to teachers, memorizing prepackaged assignments, and spitting out answers. They must talk about what they are learning, write about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves (p. 5).

Essentially, concept journaling allowed the students to take an active role in learning by opening the lines of communication, writing about mathematics, connecting student learning to previous experiences and to real-world application.

CHAPTER 5

Discussions

Using qualitative case study methodology within symbolic interactionism framework, this study examined the effect of concept journaling on the learning of seven students in a high school Coordinate Algebra classroom. The study further explored how these students perceived concept journaling as a tool for learning mathematics. Specifically, the study addressed the following research questions:

1. How does the use of concept journaling, as a writing activity, influence student learning in a high school Coordinate Algebra mathematics classroom?
2. In what ways do students perceive concept journaling as a tool for learning mathematics?

In concluding this research study, this chapter will revisit the six findings, connect the findings to relevant literature, present implications for practice, and offer recommendations for future research.

In examining the effect of concept journaling on student learning and perceptions, six themes emerged. Three themes emerged describing the effect of concept journaling on student learning in a high school Coordinate Algebra mathematics classroom:

1. Through concept journaling students learned by building associations of ideas utilizing their prior knowledge and experiences.
2. Concept journaling created a space for negotiating meaningful connections using multiple resources.
3. Concept journaling provided opportunities for constructing meaning in context via peer communications and exchanges of personal views and ideas.

In order to understand how students perceived concept journaling as a tool for learning mathematics, their voices were heard and their actions were observed. There are three themes that emerged in regard to how students perceived concept journaling as a tool for learning mathematics:

4. Students saw concept journaling as a meaningful experience to further their understanding of mathematics using real-world applications.
5. Concept journaling was viewed by students as a medium to develop an awareness of the self while immersed in meaning making contexts.
6. Students expressed a sense of connection to mathematics through the use of concept journaling writing activities.

Connections to Literature

In Chapter 2, studies were reviewed that utilized journaling writing in the mathematics classroom (Banker, 2004; Baxter et al., 2005; Grbavac et al., 2003; Koirala, 2002; Kostos & Shin, 2010; Thornton-Steele, 2007). There are similarities between the previously reviewed literature and this study. For instance, in all scenarios it was reported that through writing in mathematics, student learning improved because they gained awareness of their own thought process, they used multiple forms of representations to demonstrate mathematical thinking (Kotos & Shin, 2010), and they achieved a deeper understanding of mathematical concepts (Banker, 2004; Koirala, 2002; Thornton-Steele, 2007). This section will discuss in further detail how the results of this study relate to the findings of the empirical studies reviewed and to other published literature (Angelo, 1993; Burns, 2004; Gavelek & Bresnahan, 2009; Grossman, Smith, & Miller, 1993; Hassett , 2010; Horwich, 2006; Kaye, 1993; Maine, 2013; Pascale, 2011; Preissle & Grant, 2004; Schwarzkopf, 2003; Smith, 2010; Urquhart, 2004).

Concept journaling moved learning away from the traditional textbook style of learning and introduced a non-traditional way of learning mathematics through writing. Gavelek and Bresnahan (2009) declare when “learners read textbooks to make meaning, they are denied an opportunity to draw on their meaning-making resources (logical reasoning, problem solving, and mathematical skills) because the activity system fails to utilize students’ cultural and linguistic resources as assets for meaning making” (p. 161). Through the use of concept journaling, the classroom became a learning environment where students were engaged in creating meaningful mathematics through writing. As Burns (2004) reported, “when students write, their papers provide a window into their understandings, their misconceptions, and their feelings about the content they're learning" (p. 30). Students were able to utilize the concept journal writing activities and written responses to recognize what they understood in terms of different mathematical concepts. In addition, throughout the concept journaling process, it was apparent that the students were constantly building associations of ideas utilizing their prior knowledge and experiences through writing. By the same token, Koirala (2005) reported that "students' mathematical understanding was improved" (p. 223) through writing.

The concept journaling writing activities allowed the students to make meaning of mathematics by employing the symbols and language used within mathematics as tools to facilitate thought. Through writing students became aware that language does not carry meaning, it rather guides meaning to further understanding. Gavelek and Bresnaham (2009) argue that students “make sense of texts based on their own situated meanings about the world and they also construct meaning congruent to their identity or social position in the world” (p. 162). As students were writing mathematics, they were also making meaning from text/symbols that were provided on the concept journaling writing activity. Smith (2010) reports that, “different text

encourage thinking in different ways" (p. 70) and through the process of concept journaling, students had the opportunity to make meaning using multiple resources that they consulted while composing a written response. Hassett (2010) implies, "it is our [educators] job to provide them [students] with, and demonstrate for them, the multiple resources we have available for making meaning" (p. 91), and since the process of concept journaling allowed the students to use multiple resources, they were able to make meaningful connections. Employing the concept journaling process provided a mental space for students to read and write and in turn it became "the act of making meaning from text, in whatever its form, whether written, visual or multimodal" (Maine, 2013, p. 151). This research reported similar finding to that of Kostos and Shin's (2010) research which states, "When students write in mathematics, they are able to use multiple forms of representation to demonstrate their mathematical thinking" (p. 227).

As the students were building associates of ideas utilizing their prior knowledge and experiences, and through negotiating connection using multiple resources, they were also communicating together. The opportunity to listen to the students co-construct meaning from various text provided insight into their thinking and how they made connections of mathematics through the use of the concept journal process. As suggested by Horwich (2006), "each expression of a language surely *means* something" (p. 43), and as Pascale (2011) suggests the student "emphasizes the way definitions and shared means are worked out between people in a localized setting" (p. 103). For the duration of this study, students took the opportunity to communicate in the learning environment in order to exchange personal views and ideas which provided more opportunities for meaning to be constructed. The process of concept journaling afforded the students an opportunity where their "comprehension was enabled through creative thinking and dialogue, with children building on the ideas of each other in a dialogic space that

existed between themselves and the text" (Maine, 2013, p. 154). Banker (2004) found in her research that conversations provide opportunities for students to deepen their understanding of mathematics (p. 37) and Kostos and Shin (2010) claim a similar finding which suggests that writing provided improvement on students' mathematical thinking through math communication (p. 227). As for the finding in this research, it is reported that the process of concept journaling provided students opportunities for meaning to be constructed via peer communications and exchanges of personal views and ideas.

Concept journaling was a way to approach learning through writing. Many of the students who were enrolled in this class had previously failed the course. Students voiced they were successful in this class because of the "real-world approach" employed in each concept journal writing activity. Therefore, they were able to make more meaningful connections to Coordinate Algebra. Schwarzkopf (2003) argues that real-world word problems are an integral part of mathematics education. The students voiced that the concept journals provided experiences to transition back-and-forth between the mathematics classroom and real-world experiences, which ultimately furthered their understanding of mathematics. Kaye (1993) suggests that individuals are able to make meaning through concepts because they are able to categorize and provide knowledge through concrete real-world examples, and Thornton-Steele (2007) found that through writing, students were able to "link topics with the real-world" (p. 28). Through this research, the students voiced that the concept journaling process was a meaningful experience to further their understanding of mathematics using real-world applications.

As the students continued with the process of concept journaling, they expressed a greater understanding of their own thought process and their relationship to the classroom while they were immersed in meaning making contexts. As Urquhart (2004) proclaims, "writing fosters

community, because writing is a social act, it is a vehicle for students to learn more about themselves and others" (p. 4). In addition, the writing activities encouraged the students to think. Smith (2010) stresses that classroom practices should be established that help “children understand the patterns of thinking which they value and which will afford the children success in the educational system” (p. 69), and the concept journaling process fostered this type of classroom practice. The students suggested through the process of concept journaling, they had to be self-aware of their place within the learning environment and ready to explain what they were doing and why they responded to the writing activity in the chosen way. Angelo (1993) states, “active learning occurs when students invest and physical and mental energies in activities that help them make what they are learning meaningful, and when they are aware of that meaning-making" (p.3-4).

In addition, the students voiced that through the process of concept journaling, they became more socially connected within the learning environment. Preissle and Grant (2004) argue that “reality is seen as a construction via ongoing interaction between the self and the other society, culture in a physical and material world, and knowledge is based on meanings developed in social contexts” (p. 174). Baxter et al. (2005) identify through research that writing in mathematics "improve students' awareness of their own thought processes" and that "writing provided opportunities for students to gather their thoughts before, during, or after a class discussion" (p. 121). The findings from Baxter et al. corroborate with the findings of this research which suggests that concept journaling was viewed by students as a medium to develop an awareness of the self while immersed in meaning making context.

In addition, because the process of concept journaling took place inside the classroom and revolved around Coordinate Algebra, the students were able to sense a personal connection

of mathematics through the writing activities. Burns (2004) states, “writing in math class supports learning because it requires students to organize, clarify, and reflect on their ideas - all useful processes for making sense of mathematics" (p. 30), and these processes occurred during the concept journal writing activities. Thornton-Steele (2007) reported that through writing "the students were able to further their understanding of mathematical topics" (p. 28). The purpose of each concept journal was unique and who and what the students were writing for changed, (e.g. a contract, understanding certificate of deposits, etc.) therefore, the students had to have a connection to the mathematics to successfully compose the written response.

Kostos and Shin (2010) confirm through research "the use of math journals allows them [students] to demonstrate a deeper understanding of a mathematical concept" (p.230). The students were granted the opportunity to comprehend mathematical concepts through writing (Grossman, Smith, & Miller, 1993). As the students developed a routine of writing in mathematics, they voiced that the concept journal writing activities became a meaningful experience for learning mathematics. Ultimately, it became “a metalanguage that empower[ed] them to understand how language works in the creation of meaning across the curriculum” (Gavelek & Bresnahan, 2009, p. 152). Grbavac et al. (2003) found that "students have all gained strength in reflecting about how a lesson-affected or influenced them" (p. 59) as they make connections to mathematics through writing. Grbavac et al.’s finding align with findings of this study in that students expressed a sense of connection to mathematics by conceiving the language of mathematics as prompts to construct meanings.

Implications for Practice

The aim of this research study was to understand how concept journaling could influence student learning and to explore student perceptions in regard to using writing as a tool to learn

mathematics. Therefore, implications for practice are two-fold: writing to influence student learning in mathematics and student perceptions of using writing to learn mathematics.

With regard to mathematical writing, National Council of Teachers of Mathematics (1989) gives meaning to symbols and writing within mathematics by stating:

> The development of a student's power to use mathematics involves learning the signs, symbols, and terms of mathematics. This is best accomplished in problem situations in which students have an opportunity to read, write, and discuss ideas in which the use of language of mathematics becomes natural. (p. 6)

When students have the opportunity to incorporate writing inside the mathematics classroom, they are provided the opportunity to make connections to the real-world and to solve open ended problems. Banker (2004) affirms, "Mathematics is a precise language full of abstract symbols and notation that have no meaning without careful consideration of their purpose" (p. 15) and through writing, students can further comprehend and make meaning of the language of mathematics. This study implied that when writing and mathematics are utilized in a mathematics classroom, students have the opportunity to further develop mathematical knowledge through constructing meaning, language and thought in the context of social interactions.

There is limited literature reporting students' voices as they reflect on their learning experiences with writing in the mathematics classroom. This study explored students' voices as they reflect on their learning experiences through writing. Prusak et al. (2013) contend that when students have the opportunity to voice their thoughts, opinions, and perceptions about learning the conversations yield valuable insight and information for themselves and others. This study provided the opportunity for students to express their thoughts regarding learning mathematics and how writing could be used as to learn mathematics.

Throughout this study, students were able to utilize the language of mathematics, interpret meanings of symbols, and construct high ordered thinking skills in order to further their mathematical knowledge. The classroom became a social space where students and the teacher negotiated opportunities to interact while participating in the process of journaling. Through these interactions opportunities arose for mathematical understanding to transpire, social interactions were fostered, and students' voices were heard.

Recommendations for Future Research

Extensive literature (Banker, 2004; Baxter et al., 2005; Countryman, 1992, 1993; Dougherty, 2006; Grbavac et al., 2003; Koirala, 2002; Kostos & Shin, 2010; Powell, 1997; Thornton-Steele, 2007; Urquhart, 2009) has shown that regardless of how and when writing is incorporated in the mathematics classroom, student learning is influenced if the students use the opportunity to write to their advantage. However, there is shortage in reporting students' voices on the effectiveness of writing in mathematics. In this regard, this study proposes several recommendations for future research focusing on the need to encourage journaling in mathematics, to conduct longitudinal studies that examine the effect of writing in the retention of learning, and to explore students' voices on the use of writing as a tool to enhance acquisition of mathematics concepts.

Journaling in Mathematics. From a mathematics teacher's perspective, a suggestion would be for different types of journal writing activities to be researched in a mathematics classroom. As Wilcox and Monroe (2011) suggest, there is no right or wrong way to incorporate writing, but the overall objective is to include writing while teaching mathematics. Specifically, to what extent would concept journaling affect the mathematics classroom, the students, and/or

the teacher? How can these writing activities be employed to maximize learning of mathematical concepts?

Longitudinal Studies. Writing is a developmental construct that will be refined over time and experiences. Slomp (2012) contends that "the development of writing ability is uneven, individual, and situated" (p. 82) and Freitag (1997) argues that for writing to be truly effective, it must be used over the course of several years. Therefore, I would encourage scholars to complete studies on journal writing in mathematics for several years, tracking a group of students, to thoroughly understand how journal writing in mathematics affects learning of the student. The focus of a student's writing ability should "shift from assessing products (artifacts that point to writing ability) to tracing the trajectory of one's development over time (Slomp, 2012, p. 82).

Student Voices in Writing. This study aims to understand the perceptions of students regarding writing in mathematics. The stakeholders in education need to hear what the students are saying not just in regard to writing in mathematics, but in all domains of their learning. We should be equally tuned to the students' voices. For example, in this study the students voiced that writing in mathematics made them "think in a different way" in order to "apply" the concepts taught which allowed them to "learn better and remember it." Dahl (1995) proclaims, "Learning from children's voices allows us to know at a deeper level who children are as learners and, because we have that knowledge to expand and enrich our sense of what it means to teach" (p. 130). Therefore, there should be more research conducted that allows the perceptions of the students and their voices to be heard through published research and literature.

Final Words

As a teacher, I gradually came to understand the significance of writing in mathematics, but prior to this study, I have not taken the opportunity to hear the voices of the students in

regard to learning mathematics through writing. The purpose of this study was two-fold: one research question was posed to further gain understanding into how a writing activity, concept journaling, influenced students' learning and the other research question was posed to hear the students' voices regarding how they perceived concept journaling as a tool for learning mathematics.

The study findings further support previous literature that suggests that writing does influence student learning in particular in the mathematics classroom. In regard to this particular study, the emerging themes suggested that through writing, students were able to build associations of ideas utilizing their prior knowledge and experiences, negotiate meaningful connections using multiple resources, and construct meaning through peer communications. In addition, this study explored students' voices as they reflect on their leaning experiences through writing in mathematics. The emerging themes suggest that students perceived concept journaling as a meaningful experience to further their understanding of mathematics using real-world applications, as a medium to develop an awareness of the self while immersed in meaning making contexts and as a sense of connection to mathematics by conceiving the language of mathematics as prompts to construct meanings.

As Dahl (1995) claims, "the notion of voice is critical to understanding what children experience in school. Voice reveals the deeper meanings and perspectives of individuals and reflects learners' personal realities" (p. 124). Obviously, more research studies need to be conducted from a qualitative standpoint on hearing the voices and perceptions of the students and this research needs to appear in published literature. As educators, I believe we should utilize the voices of the students to understand how they make meaning throughout the learning process. What we hear can help us create an improved learning environment that allows for students to

further construct meaning. I agree with Burns (2004), "I can no longer imagine teaching math without making writing an integral aspect of students' learning" (p 30), nor can I imagine teaching without hearing the students' voices as they learn.

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APPENDICES

Appendix A

Concept Journal Writing Activities

Linear Functions

A. Given the following table

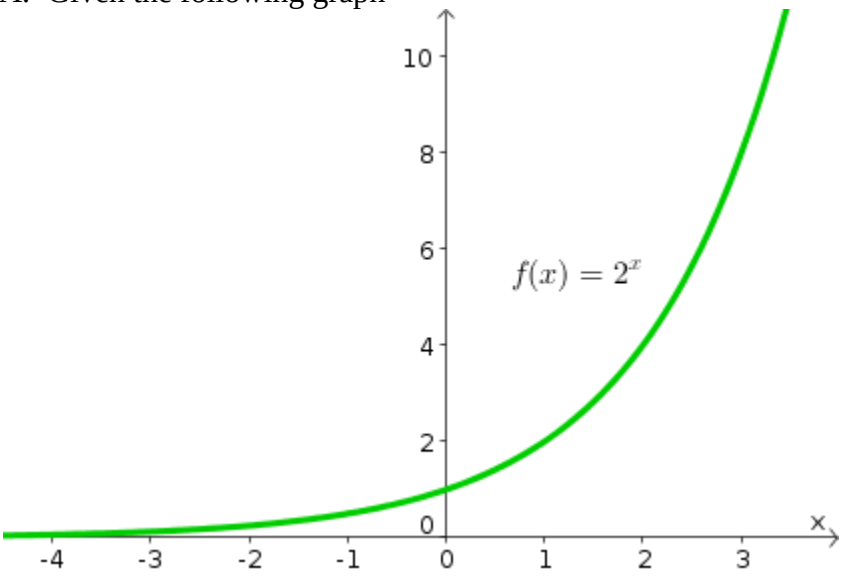
x	1	2	3	4
y	5	10	15	20

- Create a real-world example of what this data could represent
- Graph the data
- Describe in detail the key features of this linear function

B. You plan to sell your car to a friend for $4,250. Your friend cannot pay the full amount at once; therefore, you have agreed to a non-interest payment plan. Write a contract between you and your friend (include the down payment, monthly payment plan, etc.). Graph the function and create a table for the payment information.

Exponential Functions

A. Given the following graph



- Create a real-world example of what this graph could represent
- Describe in detail the key features of this exponential function

B. Utilizing the compound interest formula:

$$A = P\left(1+\frac{r}{n}\right)^{nt}$$

- Explain what each variable represents
- Using the internet find three banks that offer Certificate of Deposits (CDs) and list the interest rate for each.
- Suppose you have $3,250 to deposit into a CD for 5 years. What would the amount of the CD be after the 5 years using the three different interest rates from the banks?
- Which bank are you planning to open a CD with? Why?

Comparison of Linear and Exponential Functions

A. Identify in detail the commonalities and differences between linear and exponential functions using a Venn diagram.

B. Using images (from magazines, internet images, etc.) find three real-world examples of linear functions and three real-world examples of exponential functions
   - Cut out each example and glue to the paper
   - Identify and describe the key features of each linear function image and exponential function image
   - Compare and contrast the linear function image and exponential function image

Appendix B

Overview of Literature Review

Title	Author	Method	Purpose	Findings
The Effects of Journaling in the Mathematics Classroom	Thornton - Steele (2007)	Mixed Method -action research	to develop a writing strategy and technique that might increase critical-thinking and problem-solving at the high school level	*Quantitative* Slight increase in grades *Qualitative* Teacher noticed increased communication and justification in the classroom
Facilitating Student Learning Through Math Journals	Koirala (2002)	Constant Comparative Method & Interactive Model	if mathematical journals were able to facilitate learning of prospective elementary school teachers	Students' writing often went back to feelings and thoughts about mathematics. But, when teacher posed mathematical based problems the teacher was able to further understand mathematical thinking and respond to the students' concerns
The Effects of Journaling on Oral Communication in the Classroom	Grbavac, Piggott, & Rougeuz (2003)	Qualitative Action Research	to understand if weekly journaling inside the classroom was a means to increase communication between the students and the subject and between the teacher and the students	When the students were given the opportunity to construct and arrange thoughts on paper, the students were more comfortable communicating mathematical

Title	Author	Method	Purpose	Findings
E-journals: Reflections and Communication Improve Learning Outcomes	Banker (2004)	Qualitative Action Research	how journaling and email are used for the benefit of the teacher and students on a college campus	Teacher: able to correct misconceptions immediately and future lessons were developed based on journals Student Themes: enhanced learning experiences, increased mathematical confidence, and receiving immediate feedback
Writing in Mathematics: An Alternative Form of Communication for Academically Low-Achieving Students	Baxter, Woodward, & Olson (2005)	Qualitative -coding system	to examine what writing of low-achieving students reveals about mathematical proficiency	Increased communication
Using Math Journals to Enhance Second Graders' Communication of Mathematical Thinking	Kostos & Shin (2010)	Mixed Method -action research	investigated how the use of math journals affected communication of mathematical thinking of second graders	*Quantitative* Significant differences between pre- and post- test *Qualitative* Teacher and students noticed an increase in vocabulary, more structured writing, and mathematical explanations became clearer.

Appendix C

Assent Letter

Georgia State University

Department of Middle-Secondary Education

Title: Investigating Students' Perceptions and Learning Through Concept Journaling: An Exploratory Case Study in Coordinate Algebra

Teacher: Amber E. Steele

You are being asked to be in a research study. The purpose of this study is to utilize a writing activity, concept journaling, to understand if the activities influence students learning in a high school Coordinate Algebra mathematics classroom. Concept journaling is a type of writing activity using graphic organizers, journal reflections, ideas, drawings, symbols, or other appropriate resources to communicate and express mathematical thoughts. Participation will require 20-40 minutes a week, while in-class.

You will not have any more risks than in a normal day of life by participating in this study.

Participation in this study may benefit you by providing an opportunity for you to develop a deeper level of mathematical understanding.

Participation in the research study is voluntary. You do not have to be in this study and you may withdraw at anytime. Participating or not participating in this study will have no impact on your grades in Coordinate Algebra.

_____

Participant – Student's Name

_____ _____

Signature – Student Date

Appendix D

Consent Letter

Georgia State University

Department of Middle-Secondary Education

Parental Permission Form

Title: Investigating Students' Perceptions and Learning Through Concept Journaling: An Exploratory Case Study in Coordinate Algebra

Principal Investigator: Iman Chahine, PhD.
Student Principal Investigator: Amber E. Steele

I. Purpose:

Your child has been invited to participate in a research study. The purpose of this study is to utilize a writing activity, concept journaling, to understand if the activities influence student learning in a high school Coordinate Algebra mathematics classroom. Concept journaling is a type of writing activity using graphic organizers, journal reflections, ideas, drawings, symbols, or other appropriate resources to communicate and express mathematical thoughts. A minimum of ten students will be recruited for this study. Participation will require 20-40 minutes a week, while in-class.

II. Procedures:

We will ask all students in your child's classroom to participate. Upon your consent we will interview your child from 20-40 minutes and will observe the classroom at the start and end of the research. These interviews will be audio recorded and transcribed for further investigation. In the study we will assign weekly concept journaling in the Coordinate Algebra lessons that will be taught. The concept journal will require about 20-40 minutes of in-class time. The study's overall purpose is to gain further understanding of the students' voices in regard to writing in mathematics and how the students perceive concept journaling as a tool for learning mathematics.

III. Risks:

Your child will not have any more risks than in a normal day of life by participating in this study.

IV. Benefits:

Participation in this study may benefit your child by providing an opportunity for him/her to develop a deeper level of mathematical understanding.

V. Voluntary Participation and Withdrawals:

Participation in the research study is voluntary. Your child does not have to be in this study and your child may withdraw at anytime. Participating or not participating in this study will have no impact on the student's grades in Coordinate Algebra.

VI. Confidentiality:

We will keep your child's records private to the extent allowed by the law. Dr. Iman Chahine (Principal Investigator) and Amber E. Steele (Student Principal Investigator) will have access to the information you provide. Information may also be shared with those who make sure the study is done correctly (GSU Internal Review Board, the Office for Human Research Protection (OHRP)). We will use initials rather than your child's name on study records. The interviews will be audio recorded and transcribed. The transcriptions and other research data will be stored in a located file cabinet in the researcher's classroom. All audio tapes will be destroyed upon the completion of the study (approximately August 2015). Your child's name and other facts that might point to him/her will not appear when we present this study or publish its results. The findings will be summarized and reported in group form. Your child will not be identified personally.

VII. Contact Persons:

Contact Iman Chahine (ichahine@gsu.edu or 404.413.8407) and/or Amber Steele (amber.steele@cowetaschools.org or 770.254.2870) if you have any questions, concerns, or complaints about this study. If you have any questions or concerns about your child's rights as a participant in this research study, you may contact Susan Vogtner (svogtner1@gsu.edu or 404.413.3515) in the Georgia State University Office of Research Integrity.

VIII. Copy of Parental Permission Form:

We will give you a copy of this consent form to keep.

If you are willing to allow your child to volunteer for this research study and to be audio recorded, please sign below.

_____

Participant – Student's Name

_____ _____

Appendix E

Institutional Review Board
Acceptance Letter

INSTITUTIONAL REVIEW BOARD

Mail: P.O. Box 3999
Atlanta, Georgia 30302-3999
Phone: 404/413-3500
Fax: 404/413-3504

In Person: Dahlberg Hall
30 Courtland St, Suite 217

Georgia State University

September 22, 2014

Principal Investigator: Iman Chahine

Key Personnel: Chahine, Iman; Steele, Amber

Study Department: GSU - Middle & Secondary Education

Study Title: Investigating Students' Perceptions and Learning Through Concept Journaling: An Exploratory Case Study in Coordinate Algebra

Review Type: Expedited 6,7

IRB Number: H15121

Reference Number: 329623

Approval Date: 09/22/2014

Expiration Date: 09/21/2015

The Georgia State University Institutional Review Board (IRB) reviewed and approved the above referenced study in accordance with 45 CFR 46.111. The IRB has reviewed and approved the study and any informed consent forms, recruitment materials, and other research materials that are marked as approved in the application. The approval period is listed above. Research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the Institution.

Federal regulations require researchers to follow specific procedures in a timely manner. For the protection of all concerned, the IRB calls your attention to the following obligations that you have as Principal Investigator of this study.

Appendix F

Interview Questions

This study seeks to answer the following questions:

1. How does the use of concept journaling, as a writing activity, influence student learning in high school Coordinate Algebra mathematics classroom?
2. In what ways do students perceive concept journaling as a tool for learning mathematics?

Pre-Interview Questions

1. How would you define writing?
2. Do you write in school? If so, what and when do you write?
3. Do you write outside of school? If so, what and when do you write?
4. What is the purpose of writing?
5. What is the purpose of writing in mathematics class?
6. Do you read? If so, what and when do you read?
7. Do you thing that reading makes you a better writer?
8. Do you think writing and overall learning are linked together? If so, how? If not, why? For example, when you have a writing assignment in mathematics, do these assignments help you to learn mathematics?

Post-Interview Questions

1. We have completed several weekly concept journal writing activities? Can you describe what a concept journal is?
2. What did you think about the concept journals? Overall, were the concept journals useful or not useful to help you learn math?
3. What else can you tell me about writing in mathematics?
4. Do you think writing and overall learning are linked together? If so, how? If not, why? For example, when you have a writing assignment in mathematics, do these assignments help you to learn mathematics?

Appendix G

Observation/Reflection Journal

Date: _____