

**A PHENOMENOLOGICAL STUDY OF THE LIVED EXPERIENCES OF NON-
TRADITIONAL STUDENTS IN HIGHER LEVEL MATHEMATICS AT A
MIDWEST UNIVERSITY**

by

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A Dissertation Presented in Partial Fulfillment

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Abstract

The current literature suggests that the use of Husserl's and Heidegger's approaches to phenomenology is still practiced. However, a clear gap exists on how these approaches are viewed in the context of constructivism, particularly with non-traditional female students' study of mathematics. The dissertation attempts to clarify the constructivist role of phenomenology within a transcendental framework from the first-hand meanings associated with the expression of the relevancy as expressed by interviews of six non-traditional female students who have studied undergraduate mathematics. Comparisons also illustrate how the views associated with Husserl's stance on phenomenology inadvertently relate to the stances of the participants interviewed as part of the study. The research questions focus on the emotional association with studying mathematics and how pre-conceived opinions regarding the study of mathematics may have influenced the essences of the experiences of the participants who have studied collegiate-level mathematics. The essences of the experiences of the participants are analyzed using bracketing and *epoché* to ensure personal biases of the researcher do not affect the interpretation of the expressed essences of the participants. Data collection is accomplished through two series of qualitative interviews seeking the participants' first-hand impressions of how they view the way instructional design is oriented with regard to mathematics. Additional questions seek to illuminate the participants' point of view regarding their emotional association with mathematics as well as their opinions and theoretical perspectives on the study of mathematics.

Dedication

This dedication is with sincere gratitude to my wife, Jamie D. Wood, and daughter, Elizabeth N. Wood, whose incredible patience has made it possible for me to concentrate on my studies. I would also like to dedicate my work to my brother, Eric E. Wood, and his wife, Kelli Wood, and family, and posthumously to my parents, Larry L. Wood and Joyce E. Wood, for continually pushing me academically.

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

“Pure mathematics is, in its way, the poetry of logical ideas.” – Albert Einstein

In a modern context, mathematical instruction propagates the myth that mathematics is a perfectly constructed science (Siegel and Borasi, 1994). Due to non-traditional students, having limited mathematical exposure and experience with applying mathematics, educational institutions have created an environment whereby non-traditional students view their ability to study mathematics successfully as limited (DeHart, 2007; Bauerlein, 2008; Bettinger, Boatman, and Long, 2009; Breneman and Haarlow, 2009; Bahr, 2012). A disconnect exists academically in response to a lack of research into the design of instruction catering to non-traditional students. As summarized by DeHart (2007), a serious disconnect exists between skills necessary to be competitive in college, particularly in mathematics, and the same skills and knowledge high school graduates are expected to possess upon graduation. However, little is known regarding the educational gap involving skills non-traditional students may possess, and what preconceived cognitive limitations non-traditional students must overcome through their lived experiences and feelings when entering or returning to college in order to complete their degrees.

The purpose of this phenomenological study is to examine holistically the lived experiences of female non-traditional higher-level mathematics students in relation to their approach to the study of mathematics. The growing disparity involving mathematical experiences and exposure is potentially problematic for female non-traditional students, particularly for those who have enrolled in mathematics courses in theory several years after any exposure in secondary education. Given that the development of collegiate-level mathematics is organized for most non-technical majors involving the development of progressive theorems using axiomatic processes, the students may find even the most elementary for-credit collegiate mathematics courses beyond their scope of understanding.

By understanding the phenomenological implications of the experiences of non-traditional female mathematics students in relation to their approach to the study of mathematics, the researcher gains insight into the essences associated with the study of undergraduate mathematics. The views, concerns, and conscious justifications of non-traditional female students in the study of collegiate mathematics are of interest, particularly in reference to how consciously to perceive their challenges associated with the study of college-level mathematics.

Background of the Study

This qualitative transcendental phenomenological study addresses the question of how non-traditional female students describe their experiences in preparing for studies in undergraduate-level mathematics courses. As lived experiences mold the *behavior* of those under examination, the same affect their *expectations*. The definition of

phenomenology according to Gall, Gall, and Borg (2007) includes a “study of the world as it appears to individuals when they lay aside the prevailing understandings of phenomena and revisit their immediate experience of those phenomena” (p. 648). In this context, a phenomenon is associated with “a process, event, person, document, or other thing of interest to the researcher” and with “a sensation, perception, or ideation that appears conscious when the self focuses on an object” (Gall, Gall, and Borg, 2007, p. 648).

Even though the field of phenomenology began with Lambert in Leipzig in 1764-1765 (Schmitt, 2006; Moustakas, 1994), it was eventually followed up in Europe by Husserl from 1905-1907 and Heidegger in 1927, and Bergmann in the United States in 1954 (Stadler, 2007) in a staccato burst which helped defined modern philosophy during the 20th century. Other theorists have had similar stances regarding the definition of phenomenology. According to Moran (2007), phenomenology is a radical form of the anti-traditional method of philosophy, and according to Nenadic (2011), the purpose of phenomenology in the context of Husserl is to examine a phenomenon, which involves establishment of a basic need for understanding of a given area. However, the application of phenomenology, according to Longe (2016), is the “study of structures of consciousness as experiences from the subjective emic perspective, or first-person point of view” (p. 885).

The learning strategies and motivations of non-traditional female students regarding mathematics are expected to vary from participant to participant in the study, although with some common themes. These themes are held by non-traditional female

students as a shared experience, particularly influencing mathematical comprehension. Grassl (2010) explained mathematics competency as perhaps the greatest inhibitory cause of difficulty with non-traditional female students successfully completing coursework in college-level mathematics. The social and economic effects of the delay in completing mathematics course work, according to Grassl (2010), may negatively affect socio-economic advancement.

As a phenomenological study emphasizes distinct similarities and differences among those under examination, the study, in the words of Gubitti (2009), concentrates on determining and “emphasizing that the meaning of reality, in essence, in the ‘eyes and minds of the beholders’” (p. 11; citing Wiersma and Jurs, 2005), particularly the first-person point of view emphasizing the individual’s strengths as well as weaknesses. While the first-person perspective is objective in nature, the analysis helps define what is expected to be an objective truth. As phenomenology is considered both a philosophy and a rigorous reflective methodology according to Morrissey and Barber (2014), phenomenology as viewed by Husserl in the twentieth century was concerned primarily with the world as it was experienced not by society as a whole but by the subject from the first-person point of view.

According to Lahman and Geist (2008), the study of phenomenology includes seeking for understanding and explanation of the structure or essence of the phenomenon in question as a means of “transcendental subjectivity” (Moran, 2000, p. 2). According to Merleau-Ponty (2014), any attempt at applying scientific analysis to the atomic components of the real world, in our case the personalized phenomenological essences of

non-traditional female mathematics students, equates to an “experience error” based upon preconceptions (Al-Khalaf, 2007, p. 1). Based upon prejudices, the preconceptions include “what we know to be in things themselves we immediately take as being in our consciousness of them” (Al-Khalaf, 2007, p. 1).

In order to avoid researcher prejudices in analyzing the data collected as a result of phenomenological study, the researcher isolates him- or herself by bracketing himself or herself from the data by suspending all judgments based upon preconceived stereotypes by way of *epoché* as described by Husserl (1970) in *The Crisis of European Sciences and Transcendental Phenomenology*. This role of bracketing, according to Bogdan and Biklen (2007), involves the idea the researcher does not assume what is initially meant by the subject when a statement is made, but attempts to research the statements in order to determine and understand the underlying assumptions.

The subjective assessment of the life-world (*Lebenswelt*) is in accordance with Husserl’s (1970) assessment of the life-world (Stafford, 1973) which has dramatic implications. For instance, as a subjective topic of acquiring knowledge, the assessment involves to a certain degree an inferential line of reasoning. If the topic of the life-world were objective in knowledge, the assessment would lead to a “horizon of knowledge” (Stafford, 1973, p. 103) consistent with being beyond our level of comprehension. *Lebenswelt* (life-world) is logically expected necessarily to pre-exist any epistemological basis of Husserl’s phenomenology.

According to Erskine (2010), three principles are important in order to promote learning. For the educator, it is important to engage students’ preconceptions of the

world, to encourage the development of a deeper understanding of content knowledge, and to promote the development of metacognitive skills in order to encourage the students to manage their own learning by clearly identifying learning goals and actively monitoring their performances (Erskine, 2010). The concern of comprehending a subject by promoting a deeper understanding of content knowledge, in this case mathematics, is based upon knowing one's limitations as a hallmark of metacognition. As concerns over cognition and memory recall are concerns not only for psychologists but for educators as well, as implied by Ormrod (2012), knowing one's limitations may provide an instructor insight into which approaches may be profitable while also indicating which methodologies are problematic.

The concern of practicability in studying higher-level mathematics was once a concern when abstract mathematics is examined either by rote memorization or through the construction of axiomatic proofs. The difference between showing understanding of a subject and understanding the certainty of information with regards to mathematics represents a clear separation between instructor and student. It was found the teacher's attitudes have the strongest influence on the self-efficacy of students with regards to mathematical achievement (Kelly, 2011). For instance, if the teacher is supportive of the students and presents real-life applications of mathematics, the students in turn have a positive opinion of mathematics (Kelly, 2011). As the instructor emphasizes comprehension of a subject as a component of instruction, the students concern themselves with knowing for certain if knowledge is "fixed, unchanging, absolute 'truth'"

or a tentative, dynamic entity that will continue to evolve over time” (Ormrod, 2012, p. 375, a concern collectively known as *certainty of knowledge*.

While teachers who have a positive attitude toward mathematics encourage autonomous learning through the use of heuristics, teachers with negative attitudes toward mathematics foster a teacher-dependent attitude toward mathematics, often with a sense of helplessness (Silliman-Karp, 1988). "This autonomy develops as children gain confidence in their ability to reason and justify their thinking" (National Council of Teachers of Mathematics, 1989, p. 29; cited by Karp, 1991, p. 265; Karp, 2010, p. 265). Often any ambiguity is discharged by the instructor in the form of attitude (Silliman-Karp, 1988). If the attitude is positive toward mathematics, the attitude toward mathematics is impressed on the student as such, or if the attitude is negative it is transformed into a form of mathematical anxiety which is then impressed upon students in the form an attitude of fear towards mathematics with a self-induced sense of helplessness (Tobias, 1978; Zaslavsky, 1994; Silliman-Karp, 1988). In the general summary by Silliman-Karp (1988), females as a group are not “meeting their potential in mathematics” (p. 1).

An additional student concern involves the simplicity and structure of what they conceive of as knowledge. As simpler concepts are far easier to recall actively, knowing with a certain degree of certainty if the information is “a collection of discrete, independent facts or a set of complex and interrelated ideas” (Ormrod, 2012, p. 375) assists in the selection of learning strategies and methodologies for the assimilation and collection of information in a meaningful way. For instance, in calculus the student

learns that the structure of a function involves the input of some value, be it numerical or an independent function, which then is processed in some meaningful way by the dependent function of the problem to create some meaningful, discrete output. Here the student “learns” the concept of a function which then translates into knowledge with regard to application to calculus. To the student, knowing the difference between “knowledge” and “learning” (Ormrod, 2012) collectively establishes epistemic beliefs. As epistemic beliefs are subjective in nature, the beliefs are dynamic and subject to change by definition (Ormrod, 2012). As stated by Ormrod (2012), the domain-specific nature of epistemic beliefs becomes more pronounced with both age and grade level (Buehl and Alexander, 2006; Muis *et al*, 2006).

Statement of the Problem

A gap exists regarding a lack of research into the design of instruction for non-traditional female students in higher-level mathematics courses. How mathematical comprehension affects non-traditional female students, particularly in being successful in understanding and completing courses in collegiate mathematics, is also absent in research literature. As explained by Piatek-Jimenez (2004), and citing Dreyfus (1999), Segal (2000), and Almeida (2000), “college freshmen have limited exposure to mathematical proof[s] prior to entering college” (p. 19). While mathematics literacy is critical for students graduating high school (Morris, 2002; cited by Moore, 2005), currently the demands on non-traditional female students to academically demonstrate what they have achieved as a reasonable level of mathematical comprehension are problematic due to the lack of exposure, according to Piatek-Jimenez (2004).

In order to avoid the issue of rote memorization as a critical point of interest to modern educators as addressed by Dewey in the 1940s, curriculum designers address the subject of mathematics, particularly comprehension, in a pragmatic manner. Finally, in order for non-traditional female students to achieve the goal of demonstrating mathematical proficiency, it is necessary to establish an understanding of the mathematical framework by which non-traditional female students address mathematics from their perspective. However, currently demands on non-traditional female students to academically demonstrate what they have achieved as a reasonable level of mathematical comprehension are problematic due to the lack of exposure.

Purpose of the Study

The purpose of this descriptive phenomenological qualitative study is to examine how the lived experiences of non-traditional female students in higher-level mathematics vary among participants and how each prepares the student in the study of collegiate undergraduate mathematics. Each individual approaches the study of mathematics differently, and by understanding the strengths and weaknesses the researcher is better guided to deliver differentiated instruction to meet student needs.

Rationale

In order to understand the rationale of the study, it is necessary to understand the context upon which the study is organized, particularly phenomenology. Phenomenology essentially refers to the study of appearances, but more precisely the appearance itself of a phenomenon (Lewis and Staehler, 2011). The basis of the rationale for the study is centered on academic constructivist ideology and the personal experience of the

participants involved. With respect to the study, a student's comprehension of mathematics is evidenced through the development of axiomatic mathematical proofs. Reflection on the experiences of constructing axiomatic proofs significantly affects the essences for mathematics students.

According to Rawley (2007) women comprise the majority of non-traditional students entering college with the understanding "Mathematics education is an area where non-traditional age women tend to have difficulty" (p. vii). However, in order to understand the rationale of how the participants address the issues they faced with completing mathematical coursework in college it is necessary to identify common themes and threads by which a comparison may be made. Therefore, in order to substantiate the claims of Rawley, the study will involve interviewing six female non-traditional students to examine their lived experiences with respect to mathematical education. If the enrollment rates are accurate, taking into consideration the percentage of students requiring remediation, over 7.56 million students will require remediation.

According to Lahman and Geist (2008), the study of phenomenology includes seeking for understanding and explanation of the structure or essence of the phenomenon in question. According to Merleau-Ponty (2014), any attempt at applying scientific analysis of the atomic components of the real world, in our case the personalized phenomenological essences of non-traditional mathematics students, equates to an "experience error" based upon preconceptions (Al-Khalaf, 2007, p. 1). Based upon prejudices, the preconceptions include "what we know to be in things themselves

[yesterday] we immediately take as being in our conscious of them” (Al-Khalaf, 2007, p. 1).

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The constructivist principle of elaboration in the study involves the process of using prior knowledge to “interpret and expand” (Ormrod, 2012, p. 358) the study of mathematics. For instance, in order for a student to illustrate competency in higher mathematics, for instance in calculus, the student must first assimilate and comprehend algebra. Additionally, in order to express competency in calculus the student in question must also have the linguistic capacity to express the same. This concept is collectively known as the metacognitive strategy of scaffolding (Marge, 2001). Requiring comprehension of algebra before comprehending calculus illustrates the metacognitive strategy of scaffolding, while requiring the comprehension of the language necessary to express matters related to calculus illustrates cohort learning.

In summary, the attitude of the instructor directly influences the attitudes of the student studying mathematics. If the attitude of the instructor is positive, autonomous learning is encouraged, while negative attitudes tend to translate into instructor-dependent learning and mathematical anxiety. Additionally, acknowledging what

material is learned in a meaningful and practical way toward real-life applications encourages the crossing between learning mathematics to the possession of knowledge with regard to mathematics. Finally, in order for mathematical knowledge to be communicated between individuals, a form of linguistic coercion is necessary in order for all parties to understand what is being communicated.

Research Questions

The descriptive qualitative nature of the study examines and discovers how non-traditional female students approach coursework in collegiate mathematics. The study investigates how lived experiences influence the participants in the study successfully to complete coursework in mathematics and what common threads and frameworks exist among the participants. Additionally, how non-traditional female students approach the study of mathematics, particularly through the lens of lived experiences, is investigated. By understanding the contexts with which the participants approach the field of mathematics, the researcher understands which skills and context foster mathematical comprehension in their coursework.

The interviews with the participants will identify and characterize the commonalities and differences in approaching mathematical education. The research may draw upon these ideas, upon which instruction may be fostered in order to make mathematics education more comprehensible for non-traditional female students. The basis of the research questions provides the means for distinguishing the primary concerns of the research in a manner by which the research contributes to the body of knowledge in the field of study through an unbiased examination of lived experiences. In

this case, how do lived experiences influence how the participants approach the subject of mathematics?

Phenomenological Qualitative Research Question

How do lived experiences prepare non-traditional female students for undergraduate-level mathematics courses?

Sub-questions

What commonalities exist in the described lived experiences of non-traditional female students studying mathematics?

What differences exist in the described lived experiences of non-traditional female students studying mathematics?

Conceptual Framework

The qualitative nature of the descriptive study (Baxter and Jack, 2008) will examine how the described lived experiences influence non-traditional female students in the completion of collegiate mathematics courses. According to Merriam (2009), “a phenomenological study seeks understanding the essence and the underlying structure of the phenomenon” (p. 23). The described lived experiences of the participants are examined in the context of Husserl’s phenomenology as outlined in the text *Ideas: General Introduction to Pure Phenomenology* (1913). A comparison of phenomenology is also provided in contrast with the examination of the subject by Moustakas (1994), Creswell (2013), and Creswell and Clark (2011).

As the described lived experiences of the participants vary in some form from each other, the described lived experiences of the six female non-traditional students have

relevant scope for the study. While each participant is expected to have completed either a high school diploma or a high school equivalence exam, the abilities of each to express herself verbally is expected to be mature enough to understand not only the questioning during the interviews, but the significance of contributing to the study. The interviews with the participants will include opened-ended, non-directive questions to seek understanding as to the lived experiences of the participants with respect to the undergraduate collegiate study of mathematics.

Primarily three conceptual frameworks are under investigation. The learning styles employed by the non-traditional female students influence the manner in which they approach the study of mathematics. The motivations non-traditional female students possess influence whether the students intend to use the material addressed in the courses, or if they intend merely to complete the courses as a requirement for their desired degree programs. Finally, it is of interest how mathematical anxiety influences the methodology for addressing and studying mathematics.

As the study is concerned primarily with the lived experiences of non-traditional female students entering undergraduate studies at 25 years or older as defined by the National Center for Education Statistics (1995c, 2000), acknowledging the distinguishing characteristics of adult learners per Knowles's (1984) andragogy is necessary to outline what motivations students require in order to benefit from instruction. For instance, in young adult learners, the motivation is clearly different from that of the early adult learners, which involve primarily extrinsic motivations. As the motivations are not purely extrinsically motivated, such as those based characteristically by young adult

learners or punishment based on Piaget's (1970 or 1977) pedagogy, but organized primarily upon a sense of urgency necessitating the study of a subject; in our case, the study of mathematics. Similarly, older adult learners are more organized based upon intrinsic factors satisfying the need to learn as further addressed in Chapter 2.

Significance of the Study

The significance of the study involves addressing the common trend of experience of six female non-traditional students completing or having completed coursework in collegiate mathematics. As President Barack Obama (2009) has called for the increase of college graduates, the need for the increasing non-traditional student populations to navigate mathematics successfully is critical to achieving this goal. With an increase in non-traditional students requiring remediation in undergraduate mathematics, and with an understanding of the conditions upon which non-traditional students contend with the study of mathematics at Midwestern universities, schools may better budget academic expenditures to accommodate the number of entering freshman requiring math remediation. Without intervention, students may be discouraged from entering programs requiring a rigorous curriculum in mathematics, thus resulting in a decrease in students entering the engineering, physics, and mathematics fields.

On July 6, 2012, the significance of increasing graduates of STEM programs in the United States was determined and reported to be a concern of national security as outlined by the President's Council of Advisors on Science and Technology as reported by Gates and Mirkin (2012). The President's Council of Advisors on Science and Technology in 2012 also reported over next decade there would be approximately 3

million graduates of STEM programs (Gates and Mirkin, 2012). However, it was also estimated that approximately 60% of students who declare a STEM major often change to non-STEM programs after their freshman year, a report substantiated by Chen (2009) and the Higher Education Research Institute (2010). It was determined that reducing the attrition rate of those changing majors from STEM programs would generate an additional 750,000 graduates of STEM programs (Gates and Mirkin, 2012).

Financing STEM programs is a significant financial interest for the United States. Institutions which offer STEM majors benefit from approximately \$3.1 billion in federal grants, according to the National Science and Technology Council (as cited by Anft, 2013). In 2013, the U.S. Department of Commerce reported that STEM jobs make up less than 6% of the American workforce (Anft, 2013). However, a report compiled by 190 universities, followed STEM retention rates of entering freshmen who declared STEM majors in 2000; of those, 59% had graduated with a STEM degree by 2006 (Committee on Science, Engineering and Public Policy, 2007). While approximately 60% of the student body who declared a STEM major their freshman year changing majors before graduation, a report by the U.S. Department of Commerce states that Master's degree STEM programs primarily comprise foreign students seeking higher-level degrees in STEM fields (as cited by Anft, 2013).

Definition of Terms

Anxiety is "a subjective feeling of tension, apprehension, and worry, set off by a particular combination of cognitive, emotional, physiological, and behavioral cues" (Benner, 1985, as cited by Hart, 1989, p. 43, and Gonske, 2002, p. 13).

Axiomatic processes are mathematical axioms used to establish a mathematical claim through proofs, and are accepted as being self-evident (Rips, 1994).

Bracketing involves the delay of assuming the meaning of a statement until the statement could be fully investigated in order to determine the underlying assumptions (Bogdan and Biklen, 2007).

Constructivism holds that all knowledge is constructed from all previous bodies of knowledge and experience, and that reality is interpreted based upon experience as it is “embodied, and essentially implicates interaction with the world” (Ernest, 1996b, p. 2). The term *constructivism* is closely tied with the metacognitive concept of scaffolding (Marge, 2001).

Critical thinking is “the ability to understand, analyze, and solve problems from knowledge learned” (Forsythe-Newell, 2014, p. 1).

Efficacy means perceptions such as “people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura, 1986, p.391).

Epistemology is a theory of knowledge (Segal, 2001) concerned with the study of the nature of knowledge and how it is acquired, justified, and validated (Moser, 2001; Gall, Gall, and Borg, 2007).

Mathematical propositions have no intrinsic truth value; the statements only assume a value once the mathematical terms are defined, axioms are formed based upon assumed characteristics from the statements assuming the statement is true, certain rules of logic are applied, and the truth value of the statement is determined.

Non-sequitur statements are those in which the statement or the conclusion of the argument does not logically follow or flow from the strength of the premises (Brenner, 1993).

Non-traditional students are any students entering college at a minimum age of 25 years (National Center for Education Statistics, 1995c; National Center for Education Statistics, 2000); as cited by Linzmeier, 2014, p. 3).

Phenomenology as a field of study has different meanings depending upon the author. Husserl in the twentieth century viewed phenomenology in the context of the study of essences of experience, whereas Hegel referred to phenomenology as involving “knowledge as it appears to consciousness, the science of describing what one perceives, senses, and knows in one’s immediate awareness and experience” (Moustakas, 1994, p. 26).

Premises are propositions from which we infer a conclusion (Brenner, 1993).

Propositions are assertions or any atomic statement establishing a claim in an argument which take on some truth values (Brenner, 1993; Joseph, 2002).

Scaffolding, in the context of constructivism, involves building knowledge of one topic on another in the same field (Marge, 2001).

Soundness – an argument is sound if the argument is valid and premises and conclusions are true (Brenner, 1993; Joseph, 2002).

Syllogisms are conducive arguments where the conclusion is assumed to be true based upon the truthfulness of premises (Brenner, 1993; Joseph, 2002).

Validity – the validity of an argument holds that if the premises are true, the premises must naturally lead infallibly to a true conclusion (Brenner, 1993; Joseph, 2002).

Assumptions and Limitations

Assumptions characterize conditions that naturally exist with research participants. Each participant must acknowledge she is a minimum of 25 years in age and understands the nature of the research. Additionally, each research participant must understand that the nature of the study is to understand their lived experiences and the general purpose of the interviews, and that the results of the interviews are private. Each participant in the study must sign a Release of Information Clause in the Agreement to Participate Packet in order to participate in the study. As explained in the Agreement to Participate Packet, the participant may withdraw from the research at any time, and the participant must acknowledge that any information obtained during the research is private in nature.

Limitations are external conditions that exist restricting or constraining a study (Bloomberg and Volpe, 2012). The limitations involved in the study include the limited number of potential participants who qualify for the study, having completed the required curricular sequence of mathematics courses. Additionally, the level of archived data is limited to include only students in the Purdue University network of campuses who elect to participate in the study.

The scientist, according to Segal (2001), attempts to remove himself or herself by controlling observer bias. In order to avoid prejudices of the researcher in analyzing the

data collected as a result of phenomenological study, the researcher isolates himself or herself by suspending all judgments based upon preconceived stereotypes by way of “phenomenological *epoché*” as described by Husserl (1982, p. 30), as well as in 1970 with *The Crisis of European Sciences and Transcendental Phenomenology*, and defined by Kockelmans (1967). The principle of *epoché* involves the withholding of judgment during and following data collection as a means of not influencing the data. The final limitation for the study is only non-traditional females studying collegiate mathematics are participating in the research.

Delimitations

The delimitations of the study pertain to the selection of reference materials used through dissertations and scholarly texts associated with the study of education related to collegiate undergraduate studies of mathematics involving non-traditional students. The documents are primarily concerned with phenomenological studies. Other than the primary text sources, the documents pertain only to the study of college-level mathematics. Finally, the documents are primarily concerned with the study of mathematics in the United States and Canada.

In order to avoid the Halo Effect by the students, the researcher acknowledges the information provided does not affect the outcome of any of the student’s classes. Additionally, the information being provided is recorded in the participants’ own words, in that the essence of the experiences being investigated are not influenced by others as a result of employing *epoché*. Also, in order to avoid the Hawthorne Effect, the interviews

are conducted either at the end of the term to avoid influencing the behavior of the students employing *epoché* in order to avoid influencing the data collection.

Organization of the Remainder of the Study

The constructivist principles in education provide a framework for examining how the six non-traditional students perceive and approach mathematics. By critically examining the lived experiences and conscious decisions of the participants, and the constructivist principles, which apply, the author may determine which constructivist principles are relevant for non-traditional students involving addressing instructional design involving mathematics through the student's lived experiences.

The remainder of the study will include the literature review covering how phenomenology of mathematics is united with classic phenomenology, and how the phenomenology of logic is related directly to the phenomenology of mathematics. During the research phase, the analysis of the responses of the participants will be qualitatively assessed, categorized, and coded in order for common threads to be identified. Finally, additional avenues for research are identified in order that the research presented herein may provide insight for later analysis.

CHAPTER 2 LITERATURE REVIEW

Non-traditional students consist of undergraduate students entering college at the age of 25 or older, as defined by the National Center for Education Statistics (1995c; 2000), and according to statistics provided by the National Center for Education Statistics (2011), nearly 43% of all undergraduate students require remediation in one or more fields of study (Aud *et al*, 2011; cited by Watson, 2015, p. 2), a significant increase from 28% seven years earlier (Grassl, 2010, p. 2). Likewise, according to Linzmeier (2014), citing the National Center for Education Statistics, “between 2000 and 2009, undergraduate enrollment in degree-granting postsecondary institutions increased by 34 percent, from 13.2 to 17.6 million students” (pp. 4-5), with an estimated 19.7 million students projected to be enrolled in college by 2020 (2011, p. 34).

According to Gubitti (2009), of those students in community colleges, 94% require remediation, whereas 83% of all students in community colleges require remediation in mathematics (p. xiii). However, a lack of information exists regarding what percentage of non-traditional students require remediation in mathematics. According to Rawley (2007), the growing percentage of non-traditional students is female, and if the percentage of non-traditional students requiring remediation is consistent, with a growing population of non-traditional students entering college also

requiring remediation, a great educational economic dilemma is developing. Statistics have shown that while the test scores in mathematics have drawn approximately even between the sexes, the number of men and women studying mathematics in college has also drawn significantly closer, with women taking advanced mathematics courses about as regularly as men (Chacon and Soto-Johnson, 2003; Hill, Corbett, and St. Rose, 2010; National Center for Education Statistics, 1995a; 1995b). However, a significant portion of female collegiate students still refrain from entering programs which rely heavily upon mathematics such as those involving physics, engineering, and computer science as found by Cavanagh (2008), Catsambis (2005), Dick and Rallis (1991), and Hanna (2003) (as reported by Adeyemi, 2010).

In order to understand the conditions which have propagated the disposition of the dilemma involving female collegiate students refraining from entering STEM programs, it is necessary first to grasp and understand the composition of the student body. As the number of students immediately entering college after high school has dropped, according to Rawley (2007), the number of female students classifiable as non-traditional has increased (Padula, 1994; Scott, Burns, and Cooney, 1996). In 1990, the U.S. Department of Commerce reported (1990) (as cited by Rawley, 2007, p. 1) in 1988 the number of students in college consisted of 13.1 million students, of which 48.6% are female, consisting of the total growth of students between 1980-1988. In contrast, in 2011 the U.S. National Center for Education Statistics reported the number of students in college was approximately 19.7 million, an increase from approximately 14.4 million

students in 1991 (as cited by the U.S. Census Bureau), with the U.S. Census Bureau (2011) reporting females consisted of approximately 56% of college students.

While the U.S. Census Bureau has traditionally sought feedback from surveys by phone and self-reporting mail correspondence, the trend of business and government agencies was for an increased reliance upon internet-based self-reporting of critical data. While the U.S. Census Bureau has continued to use mail correspondence as a means of self-reporting, the U.S. Census Bureau (2014) reported the number of female students in college decreased to approximately 10.5 million, with 3.9 million, or 37.7%, classified as non-traditional. This significant discrepancy is possibly attributable to colleges and universities refraining from openly reporting on student enrollment out of privacy concerns regarding student safety. As well, private colleges and universities also refrain from reporting basic student demographic information since they do not rely heavily on federal funding to operate.

Demand for Remediation

Decades of emphasis on mindless implementation and memorization has created an environment in which a drastic decline of enrollment in advanced mathematics, science, and engineering courses was noted between 1960 and 1995 (West, 1995); a trend noted by the United States General Accounting Office (GAO) and National Science Board (NSB) (Moakler and Kim, 2014). However, the field of education, following the developments from approximately 1960 through 1995, saw a slight increase of interest in the fields of mathematics, the sciences, and engineering during the latter part of the 20th century, as reported by Miles, van Tryon, and Mensah (2015). The consequence was a

significant increase in the necessity for remediation of collegiate students, particularly in mathematics (Greene and Foster, 2003). Consequently, Bettinger, Boatman, and Long (2013) reported that in 2003, among the entering college freshman, a significant percentage (nearly 1/3) required remediation in mathematics (citing Braswell *et al.*, 2003). These findings were inconsistent with the findings of the GAO and NSB who reported a significant decrease in the presence of graduates of STEM programs in the United States (Moakler and Kim, 2015).

By the later part of the 20th century no longer was it sufficient for students to memorize every detail of instruction in order to be a productive member of society. As described by Tsui (1998), fostering critical thinking is a safeguard for a democratic society, and with an increase in new technology, employers have continually placed an emphasis on a workforce of better critical thinkers. The National Council of Teachers of Mathematics (NCTM) (2000) announced a call for students to not just memorize mathematical facts, but to understand the purpose of mathematical instruction as a means of creating better thinkers. The elaboration of the purpose of the mathematical educator, as well as the perceived expectations of the student, occurs in detail in Chapter 2.

By 2015, 80 years after the call for the same by Dewey, educational goals have changed significantly to include the transition of students to become better thinkers called for by both educators and industry. The goal of the improvement of mathematical comprehension involves the understanding of proof formation and structure in the context presented. With a forecasted growth in the fields of computer technology, healthcare, and engineering according to the United States Department of Labor in 2010-2011

(Miles, van Tryon, and Mensah, 2015), of particular interest in application is for high school and collegiate studies for potential students in science, technology, engineering, and mathematics (STEM) programs to promote the development and understanding of critical thinking. The result of the training is to assist students in becoming better thinkers and to encourage entry into competitive STEM-based careers.

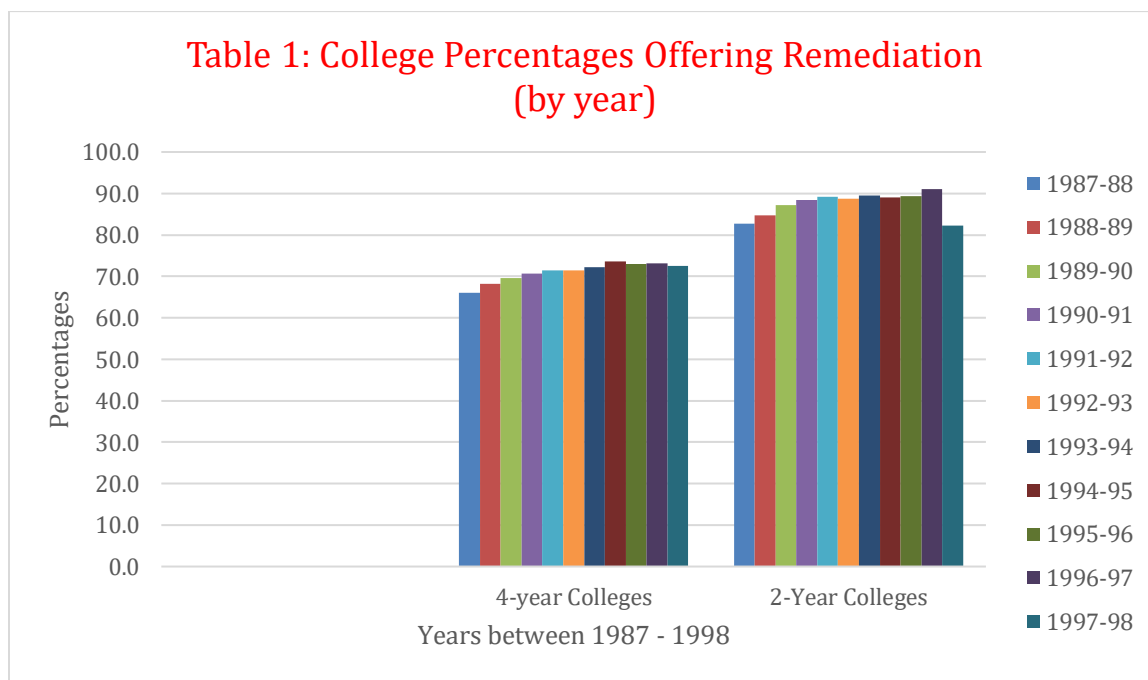
According to the Moakler and Kim (2013), approximately 45.5% of high school students list STEM programs as their probable major, which is contradicted by findings of the National Academy of Sciences, which found that interest in STEM programs had significantly declined by 2007 as illustrated in Appendix C. The 2013 National Survey of Student Engagement reported that for every 100 students enrolling in a STEM program in the fall of their freshman year, 24 leave for non-STEM majors by spring (Berrett and Sander, 2013).

Often the administrations of colleges and universities claim that the cost of remediation is the reason why a university or college restricts access to any remediation, and have called remediation, according to the California Post-Secondary Education Commission (1983), the “curse of American higher education” (p. ix). However, Breneman and Haarlow (2009) reported remediation costs approximately \$1 billion dollars a year out of an approximate \$115 billion spent in total on education, equaling less than 1% annually.

Forbes (1997), citing Scott (1987), reported that while the University of California system on average admits only the top 12% of graduating seniors for undergraduate studies, half of all new freshman require remedial courses (p. 3), with

nearly 1 in 3 students, as previously reported, requiring remediation in 2003 (Braswell *et al*). The summary of the percentages of colleges offering remediation is expressed in Table 1.

Forbes (1997) reported that the cost of remediation (in 1982 terms) accounted for \$5.5 million in educational costs (p. 3), which in 2016 terms accounted for approximately \$13.5 million. Likewise, the U.S. Department of Education reported in 2003 approximately 75% of all two-year and four-year colleges offered remediation as part of the available curriculum (cited by Howell, 2011, p. 292). Consequently, the U.S. Department of Education reported approximately 28% of freshman require remediation (Parsad and Lewis, 2003; cited by Howell, 2011, p. 292).



Source: U.S. Department of Education, National Center for Education Statistics. (1999). Integrated Postsecondary Education Data System (IPEDS), "Institutional Characteristics" surveys.

As of 2007, California reported 37% of students entering California State University required remediation in mathematics during the fall of 2006, with 46% of students unprepared for collegiate English studies (Bauerlein, 2008, para. 3) as well. In comparison with Scott (1987), the report by Bauerlein (2008) placed into perspective the data reported by Bettinger, Boatman, and Long (2013), who stated 35 to 40% of entering freshmen needed remedial or developmental courses upon entering college, and 1 in 3 students graduating high school students were college-ready (p. 93).

In contrast, the Massachusetts Department of Education in 2007 reported nearly 37% of incoming students required remediation in at least one subject (Bauerlein, 2008, para. 4). Likewise, in 2006 Ohio public colleges and universities reported that approximately 38% of incoming students required remediation (Talbert, 2006, para. 4). Finally, Talbert (2006) reported that among Ohio colleges and universities 15% of students who graduated with Bachelor's degrees required remediation while 85% of students who graduated with Bachelor's degrees did not require remediation (para. 3).

In the case of mathematical remediation, the conflict develops in how mathematics students associate critical thinking with mathematical comprehension. According to Solow (2013), during the establishment of conclusive mathematical proofs, statements or claims are expressed which may be true or false in nature. However, these

statements commonly conflict with the fact that the information in the argument is conclusively true.

The role of critical thinking in this context involves the intellectual construction and assessment by the student who is constructing the proof under the belief that premises naturally lead to the conclusion regardless of the truth values of the statements. While the introduction of the techniques for constructing axiomatic proofs traditionally occurs in geometry, the advanced study of mathematics at the level of calculus and above is a relatively recent development requiring training. Critical thinking is needed in order to substantiate proofs beyond those satisfied simply by citing axioms and theorems discovered over two millennia earlier.

Causation of Non-Traditional Students' Recidivism

The cause of non-traditional female students' leaving college was addressed in 1997 by Anderson, who identified several common key themes which led non-traditional female students to drop out of college before completion of their degrees. Perhaps the most common theme found by the author and one of the common themes identified through research by Rawley (2007) involves the fact that many students have had a bad experience studying mathematics at an earlier age and tended to avoid studying mathematics unless absolutely necessary. As academic proficiency is illustrative of a student's sense of efficacy, understanding efficacy as perceptions such as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p.391) leads to the understanding that

non-traditional female students' sense of self-worth may be a factor in successfully completing studies in collegiate mathematics.

Before the establishment of equal access to a collegiate education by all genders, the research conducted by Rawley during the 1980s found the standard by which all academic measurement was established through the activities of males, which statistically represented the vast majority of students enrolled in college (Cohler and Boxer, 1984; Okun, 1984). The sexist stance was an unofficial standard by which academia was assessed before the establishment of equal educational rights, be it by legislation, policy, or social conditioning. However, as academia has changed progressively since 1984, so have the standards by which all academic achievement is assessed.

Legal Precedence

In the age of gender equality, the standards by which academic proficiency is assessed have moved from a pure gender construct to that of academic gender equality. The equal right to education is considered a universal entitlement, regardless of gender or race. Statistics reported by Marklein (2015) found that in 2005, 57% of the students in colleges and universities were female and 43% were male. Equality of access to a high-quality education has become a politically charged subject since the passing of the Equal Access Act (20 U.S.C. § 4071) in 1984, which established equal access to extracurricular and secular activities, regardless of gender, under Title IX (20 U.S.C. §§ 1681–1688, 1972). Additionally, following *Pfeiffer v. Marion Center Area School District* (1990) it was found an individual has the right to access to extracurricular activities such as the National Honor Society (NHS), regardless of sex. The significance of the cases

established that the rights of students to curricular and extracurricular activities may not be denied based upon gender or condition.

Avoidance of Mathematics

A trend exists where secondary and post-secondary students, and adults in general avoid the study or use of mathematics (Gonske, 2002). Math anxiety, as it is commonly called, is based upon the preconception that the student is incapable of being proficient at mathematics while remaining more than capable in other academic fields, summarizing their condition with the claim, “they ‘just can't do math’” (Gonske, 2002, p. 1). As a result of the shared phenomenological experience, the avoidance of taking high school mathematics courses leads to students’ being ill-prepared to study undergraduate collegiate mathematics. Even though non-traditional students may find they have to use mathematics in most activities of daily living and do so rather efficiently, the same students find they develop anxiety when studying mathematics. This sense of anxiety associated with the undergraduate study of mathematics based upon previous bad experiences in secondary education still exists as a profound issue.

Tsui in 1933 found language itself is too expressive for it to be practical for the expression of mathematics due to its own intrinsic truth values assigned through the language itself (Krause 2012). Just as the experiences of studying mathematics create subjective meanings to students as implied by Locke in *An Essay Concerning Human Understanding* (1996), it is possible to understand how the shared experiences create an objective experience for students sharing the same anxiety.

The level of expressibility requires a degree of separation between how the mathematical expressions are constructed and assessed based upon their own merits. Mathematical expressions like typical statements have no intrinsic truth value until they are assessed. Therefore, in order properly to assess the validity of mathematical expressions, it is typically best to assess the same based upon the logic employed in the construction of the proofs.

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Mathematical Anxiety

Mathematical anxiety, as it is addressed by Tobias (1978; 1993), includes the phenomenon whereby an individual “has feelings of mental disorganization, fear, or even panic that prevent people from effectively learning or working with mathematics” (Gonske, 2002, p. 2), and mathematics produces anxiety only when it is perceived as a psychological threat (Cemen, 1987; as cited by Gonske, 2002). Mathematics has been described as the “critical filter,” advertently, particularly with women in non-mathematical fields (Gourgey, 1982, p. 1; Sells, 1978). As fear or panic is a possible natural reflex in response to a stressor, the irrational basis of the anxiety is addressable by

avoiding the subject matter in a reasonable and logical fashion to ascertain the nature of the material and to see how the mathematical stressor must adhere to simple reasoning. As explained by Gourgey in the early 1980s, mathematical anxiety is indiscriminate as to which sex it affects, and regardless of professional background, the condition affects females far more often (Betz, 1978; Hendel and Davis, 1978; Kogelman and Warren, 1979; Tobias, 1978).

The effects of mathematical anxiety can transfer to other aspects of non-academic life due to the development of mental, emotional, or physical reactions (Ashcraft, 2002). Students with high levels of mathematical anxiety avoid mathematics and take fewer elective mathematics courses in high school as well as in college (Ashcraft, 2002). This anxiety may be interpreted as the reason undergraduate students tend to avoid STEM programs. According to Ashcraft (2002), these students receive lower grades in mathematics courses than students who view their abilities as positive in studying mathematics, and as a consequence have negative attitudes towards their mathematical abilities.

Academic Disparity in Mathematics

Traditionally, in secondary education basic mathematics is taught for several consecutive years until a point is reached upon which students are capable of understanding the abstractness of mathematics in their first introductions of pre-algebra and algebra. The abstractness of algebra is paradoxical for some students who think of mathematics in purely concrete terms. In college mathematics, primarily those involving programs stressing STEM, the heavy reliance upon abstract mathematical concepts may

present a barrier to studying advanced mathematics. When a student in secondary education struggles at a young age to grasp abstract mathematical concepts such as those now introduced in junior high and high school, the student is more prone to avoid studying any courses due to mathematical anxiety, which in turn, would require addressing the shortcoming (Gonske, 2002). Even following the introduction of the No Child Left Behind Act of 2001, educators were burdened with covering as much material as possible in order for the student to be exposed to the greatest amount of material in preparation for the standardized testing most states required.

Standardized testing is used as a benchmark for schools in order to qualify for additional federal funding. Examples of the benchmark testing used to determine which schools and school districts qualify for additional funding are associated with high-stakes testing such as the Indiana Statewide Testing for Educational Progress Plus (ISTEP+) program. A criticism of the high-stakes testing in Indiana has concentrated on proving that although students are learning more, the students may actually be falling further behind than other students who grasp abstract concepts such as those posed in algebra and geometry, for the sake of funding due to academic time restraints.

College Preparedness

As adults are seeking to continue their education in colleges and universities, some for promotions and others to acquire additional marketable skills, the students who refrained from studying the more abstract courses in mathematics are finding they are ill-prepared for the study of collegiate mathematics due to mathematical anxiety (Ashcraft, 2002). While adult students possess the ability to use abstract thought in a more

productive manner than when they were being educated in K-12, the continuation of the avoidance of mathematical courses (Ashcraft, 2002) still poses a situation upon which the avoidance is proving to be problematic when the student enters a STEM program, due to its heavy reliance on advanced mathematics. Additionally, as a growing population of students are classifiable as non-traditional, the skills of abstraction may additionally be weakened due to the delay between secondary education and college. Thus, by concentrating on proving students are learning more, the students may actually be falling further behind than other students who grasp abstract concepts such as those posed in algebra and geometry for the sake of funding due to academic time restraints.

Cost of Educational Shortcomings

College students' recidivism has a profound economic effect. In 1991, Francis cited *The Unfinished Agenda: A New Vision for Child Development and Education*, written by the Committee for Educational Development (CED), which reported that for each class of freshman students leaving after the first year of college, theoretically, a combined reduction in income of \$237 billion occurs over a lifetime for these students (cited by Forbes, 1997, p. 5), which in 2016 terms equates to approximately \$412 billion. With college algebra, a typical core course in mathematics for students in community colleges, the growing need for remediation for incoming freshman in college algebra has a profound academic as well as economic significance in recidivism, particularly in entry-level mathematics. In order to better prepare students for high-tech employment called for by President Barack Obama (2009), students need additional training in the development and employment of critical thinking, a fact emphasized by Coates (2014).

According to Woodhams in *The Chronical of Higher Education* (1998, December 2), the costs of remediation have not significantly increased. In addition, the cost of post-secondary education has increased, possibly contributing to the fact that of the 50% of high school graduates attending college, 40% complete an Associates, Bachelor, or other degree, as reported by Mulrine (2010) (cited by Christmas, 2015, p. 3). According to Christmas (2015), in relative terms, remedial courses cost higher education institutions over \$1 billion dollars per year, values consistent with Breneman and Haarlow from 2009.

A fierce debate exists regarding the continuance of college remediation, based purely upon budgetary considerations. Arguments against remediation with the greatest merit include those that suggest the need to offer remediation over entrance into technical programs only to those who theoretically are capable of comprehending the required information successfully, with a minimal amount of intervention. According to Carter (2013), the costs of remediation at the collegiate level are associated with an increase in tuition for students overall, with an increase in tuition rates for two-year colleges of 14%, and 42% for four-year colleges (para. 7). An additional point of contention includes the fact that remedial courses are not for credit-earning and cannot be applied towards a degree.

Economically, a failure to complete a college degree once a student enrolls in a two-year or four-year institution has significant consequences. Following the establishment of privatization with the decrease of state funding for post-secondary education, the economic shift of dealing with post-secondary education has shifted away

from the States and to the growing establishment of student loans (Chen and St. John, 2011). In addition to the monetary loss for students who failed to complete a college degree, the tuition costs increased and resulted in a serious reduction in available college-level program resources and program competitiveness. As a consequence, the question can be asked, how much is student loan debt attributable to paying for the costs of college student dropouts and for those requiring remediation?

Still, for many, getting a college education is worth the investment in time and money. Additionally, when viewed from a professional point of view, the ability to network may prove to be highly beneficial to students when seeking additional contacts in the field of their study. Finally, the completion of a college education may provide the means for the students to establish a path for career advancement or to seek employment in other more marketable fields of interest.

Woodhams (1998, December 11) stated that the number of freshman students in remediation has increased to nearly 56% of students, over half of whom are over the age of 22, and nearly one quarter of students in remediation are over the age of 30 (para. 3). Woodhams (1998, December 2) also stated 1% of public institutions' budgets and nearly 2% of total higher-education expenditures are associated with remediation (para. 4). With the call by President Barack Obama (2014) for more graduates capable of filling high-tech jobs (2009; cited by Boggs, 2010), it logically follows more educational and financial support are required in order for the growing number of students to complete their education.

Theoretical Framework

The theoretical framework upon which the phenomenology of mathematics is approached involves not the steadfast reliance upon experience to the formation of knowledge as suggested by Whitehead (as noted by Moustakas, 1994), but the act of intentionality (Sokolowski, 1999) actively to conceptualize of information seen through the lens of logic to express itself. First and foremost, reality must comply not with a conformity to experience, as stated by Moustakas (1994), but with the conscious act of acknowledgement and assimilation. The act of conceptualization is a conscious act, and as such negates the distinction established by Heidegger's (date) *noema-noumena* which explained that knowledge is gained both by conscious volition and by unconscious accommodation.

As the theoretical framework of the study is concerned primarily with the lived experiences of non-traditional female students, as defined by students entering undergraduate studies at 25 years or older by National Center for Education Statistics (1995c, 2000), acknowledging the distinguishing characteristics of adult learners per Knowles' (1984) andragogy is necessary to acknowledging and outlining what motivations students require in order to benefit from instruction. As the motivation to learn becomes less reliant upon the actual knowledge and extrinsic motivation, commonly associated with younger adults, concentration is more oriented to involve the actual thought process by which knowledge is acquired and applied, paramount to intrinsic motivation.

The influence of Vygotsky and Dewey in the twentieth century on Knowles is based on the labeling of social constructivism. As Dewey was labeled as a social constructivist according to Phillips (1995, p. 7; 2000, p. 13) based on his traditional approach to education, Vygotsky's labeling with other social constructivists including Piaget and the radical constructivist Von Glasersfeld was focused on the social influences of individual learning and stressed the role played by language in shaping the individual's construction of knowledge. According to Johnson (2003), as explained by Vygotsky in the 20th century, "The [underappreciated] role played by the vast cultural repertoire of artifacts, ideas, assumptions, concepts, and practices which the individual inherits or is 'born into'" (p. 11).

The constructivist principles as identified by Bruner and Moshman highlight common characteristics with epistemological justification. For instance, Bruner explained that epistemological justification of learning involves an active process by which the individual evaluates the information based upon previous bodies of knowledge (Culatta, 2016). As the body of knowledge is used to form hypotheses regarding the relevance of the information, it is also used to assimilate the information as a new body of knowledge (Culatta, 2016).

Moshman's characterization of constructivism's epistemological justification is based upon exogenous, endogenous, and dialectical aspects. Exogenous constructivism, according to Moshman, assumes that an external reality exists and that it is reconstructed as knowledge is formed (Applefield, Huber, and Moallem, Dec 2000/Jan 2001). The endogenous approach to constructivism also known as cognitive constructivism (Cobb,

1994; Moshman, 1982) is representative of a thorough focus upon the internalized, individual connections of knowledge primarily based upon the Piagetian theory (1977; 1970) (Applefield, Huber, and Moallem, Dec 2000/Jan 2001). Finally, dialectical constructivism, also referred to as social constructivism, bases its origin of knowledge construction on the “social intersection of people, interactions that involve sharing, comparing, and debating among learners and mentors” (Applefield, Huber, Moallem, Dec 2000/Jan 2001, p. 38).

Pedagogy

The development of education based upon the characteristics of the learner developed into what was referred to as pedagogy. By acknowledging the learning styles of the student and goal of the instruction, educators developed various methodologies intended to best reach the student and to propagate learning. As stated by Conaway (2009), “children are basically dependent and function with external direction and motivation, [while] adults perform best in an autonomous, self-directed environment” (p. 4; Zmeyov, 1998).

According to Conaway (2009), pedagogy as it relates to school-age children is based upon five assumptions. First, it is assumed students, predominately school age, do not possess enough basic knowledge to function productively, and as such, are dependent upon the teacher to provide said knowledge to satisfy their learning needs (Ozuah, 2005; Forrest and Peterson, 2006). Second, the instructor assumes the responsibility of effectively communicating this knowledge to the student. Third, learning is expected to be subject-centered and the student must adapt his or her learning methodology to fit his

or her learning style to the subject matter at hand (Ozuah, 2005; Conaway, 2009).

Fourth, the primary driving force for learning is extrinsic in nature, be it culturally or as the result of home environment, and as such are punishment-based. Finally, students do not possess the experience to justify ignoring the instruction focused loosely upon Locke's *tabula rasa* (1996 [1689]), or "blank slate" ideology.

It was not until the latter part of the 20th century that pedagogy was further supplemented as an instructional design (Conaway, 2009) by Knowles's (1984) andragogy. One of the most significant critics of learning pedagogy in the early 20th century was Dewey, who criticized pedagogy's constructivist influence in instruction, which heavily endorsed reliance upon rote memorization. Dewey did not consider himself a constructivist *per se*, but according to Bentley (1998), his epistemological work was considered "consistent with much of constructivist thought" (p. 238) (as cited by Johnson, 2003, p. 3). The work of Dewey and Vygotsky eventually influenced the work of Knowles's (1984) andragogy by the latter part of the 20th century (Johnson, 2003). By that time the topic of pedagogy was further addressed and supplemented by Knowles's (1984) theory of andragogy which helped identify the motivations of adult learners.

Andragogy

The concept of Knowles's (1984) conceptualization of adult learning, what he called "andragogy," is associated with adults being intrinsically motivated, self-directed learners by necessity, and conditioned by experience (Conaway, 2009). According to Knowles (1988), adult orientation involves a shift in learning from a subject-centered to a problem-centered point of view, and that adult satisfaction shifts from an external

influence such as those with children into something internally meaningful (Zmeyov, 1998). Andragogy was more concerned with addressing the actual thought process and with a decreased emphasis upon what exactly was being learned.

According to Conaway (2009), Knowles (1984) was motivated to re-examine instructional design as a means of improving upon pedagogy due to political and fiscal pressures of the time. Motivated by Dewey and Lindeman in the United States, and Savioevic from Yugoslavia, Knowles (1984) acknowledged the presence of intrinsic and extrinsic motivations in learning (Conaway, 2009). The intrinsic nature of motivation to learn in adults is based not purely on a need to know, but on the basis that the process of learning would satisfy some need, whether intrinsically or extrinsically motivated. Additionally, the motivation, regardless of either cause, must comply with self-developed sense of logic justified by experience.

Emerging Adult Learners

The self-directed nature of learning in adults is associated with the experiences noted by the same which organize learning into a series of successful schemata. As identified by Knowles (1984), and reiterated by Conaway (2009), younger adult learners between the ages of 18 to 25 are typically extrinsically motivated similar to school-age children as outlined by Piaget (as identified by Ormrod, 2012). The reinforcement of learning in young adults is consistent with the acknowledgement that learning satisfies some need, either intrinsically motivated biological or psychological, or socially by cultural necessity and conditioning. As intrinsic motivations lie within the individual or task (Ormrod, 2012) and extrinsic motivations lie outside the individual, the result is to

generate a response (Ormrod, 2012). The biological nature of the motivation involves the intrinsic need, and socially extrinsically reinforced need to propagate (Conaway, 2009). Thus, learning may have some external justification in order to satisfy these needs, even when the satisfaction is intrinsically driven, and the justification must be acknowledgeable by the same individual (Conaway, 2009).

In younger adults, as well as typically in school-age children, social conditioning was the primary motivation for education. The example presented by Conaway (2009) explained how during the Middle Ages children were educated by the Church with the intention that the student would eventually enter the priesthood. As society during the Middle Ages was centered upon the support of the Church, the basis of education was limited by supporting the development of the same. For the children of that time, the social conditioning was purely extrinsically motivated and reinforced (Ormrod, 2012).

Middle Adult Learners

Unlike the purely extrinsic motivation associated with young adult learners, the motivation of middle adult learners aged 26-39, is less immediately extrinsically motivated. With respect to the research, the organization of a mathematical schemata is logical in orientation, even when the immediate need or sense of urgency in learning is not immediately apparent. Additionally, the development of mathematical schemata is intrinsically motivated in the satisfaction of social issues which influence the outcome of the individual (Mansukhani, 2010).

Older Adult Learners

Older adult learners, according to Conaway (2009), represent adults ranging from 40-59. Even though Knowles (1984) established a theoretical upper limit to learners, it is generally accepted by educators every student is capable of learning regardless of age. Unlike younger adult learners, nearly all learning associated with older adult learners is almost purely intrinsically oriented.

Creation of Constructivism

Academically, the topic of pure constructivism is a recent addition, even though several components which are classifiable as constructivist in nature have existed for over two millennia with theorists such as Von Glasersfeld (1989) and Yager (1995) viewing the origins of constructivism as having existed since the 19th century with the works of Vico (cited by Power, 1997). Constructivism in the latter part of the 20th century has emphasized child-centered pedagogy, investigating how knowledge is constructed (Phye, 1997). While constructivism provides a convenient means of expressing the concept by fostering critical thinking as expressible through mathematical comprehension, it is still considered a rather vague term to label a rather complex subject (Anderson, Reder, and Simon, 1998).

According to Hairston (2003), contemporary educational theorists view constructivism as a paradigm switch from passive learners to active learners on purely semantic grounds. However, according to Anderson, Reder and Simon (1998), simply asserting that a learner is active in the acquisition of knowledge or the making of connections with previous knowledge makes a claim considered fundamental for all

cognitive theories not solely constructivism. Finally, claiming students are active learners when employing constructivism is based on the pejorative establishment of a “straw man” argument and description which establishes the counterstance which in itself is unsupportive (Anderson, Reder, and Simon, 1998).

Von Glasersfeld asserted, “In the past decade or two, the most important theoretical perspective to emerge in mathematics education has been that of constructivism” (1995, p. xi; cited by Hairston, 2003, p. 4). Constructivism is conceptually different from Dewey’s pragmatism; as a result it does not attempt to copy or mirror outer reality in the mind (Hickman, Neubert, and Reich, 2009), but the participants are “observers, participants, and agents who actively generate and transform the patterns through which they construct the realities which fit them” (Hickman, Neubert, and Reich, 2009, p. 40).

In mathematics, an illustration of constructivism with respect to increasing mathematical comprehension is representative of expressing the concept of a function in calculus. Before the concept of a function is understandable to a student, the concepts of algebra must be addressed and comprehended. Additionally, the concepts of algebra must be interpreted as being logical before an individual can apply them to the study of calculus. If a student can illustrate comprehension of functions in calculus logically, the student naturally illustrates comprehension of algebraic expressions and manipulations. This reasonable construction of concepts from one mathematical subject to the next is illustrative again of scaffolding.

Bruner

With respect to a constructivist as an example of an anti-realist, a fact is meaningless unless the fact can be conclusively justified or established. Mathematical facts themselves are justified by axiomatic means in the formation of proofs. The work of Bruner highlighted several key features in order for this to occur. First and foremost, the individual must have a disposition to learning. As Locke (1689) described the mind of the individual as a blank slate (*tabula rasa*), the individual must have some lack of knowledge regarding the subject at hand in order for the disposition to learn to present itself. Before the individual can evaluate or justify the necessity of examining information, the individual must have some sense of “empowerment” (Bogdan and Bilken, 2007, p. 243) to justify the expenditure of energy, time, and possibly finances.

An additional key characteristic of Bruner’s theory regarding the epistemological justification of learning involves an active process by which the individual evaluates the information based upon previous bodies of knowledge, forms hypotheses regarding the relevance of the information, and assimilates the information as a new body of knowledge (Culatta, 2016). The individual must expend some remarkable amount of energy during the active process before the assimilation of information is meaningful. The topic of an active learner is thoroughly addressed under the section involving Hairston (2013). The third key characteristic of Bruner’s theory regarding the epistemological justification of learning incorporates the formation of schemata as a means of associating the new body of knowledge with pre-existing bodies as addressed under andragogy. The fourth characteristic of Bruner’s theory regarding the

epistemological justification of knowledge involves using rewards and punishments as a means of endorsing the acquisition and use of new bodies of knowledge (Culatta, 2016).

Constructivism as it relates to mathematics is an anti-realist, *a priori* stance specific to mathematics in response to Platonism, which holds that mathematical objects or mathematical truths are not independent of the individual, but dependent upon the mind of the individual (Carnap, 1995; Ormrod, 2012). While during the early part of the 20th century constructivism was labeled “intuitionism” as a result of the works of Brouwer in opposition of positivism (Gall, Gall, and Borg, 2007), in the latter part of the 20th century the stance required revising several key features associated with classic logic. According to Friend (2007), the constructivist holds “the logic guiding the construction of mathematical objects has to be epistemically constrained” (p. 101). For instance, according to the constructivist, applying logic to the construction of knowledge, particularly mathematical concepts, the concept of the excluded middle is acceptable as a means of establishing a mathematical truth, as are arguments based upon *reductio ad absurdum* and double negation elimination (Friend, 2007).

Moshman’s Constructivism

The characterizations of Moshman’s constructivism is based upon the context upon which the field is applied. While exogenous constructivism under Moshman is concerned with the philosophical examination of an external reality with focus upon the internalized, individual connections of knowledge primarily based upon the Piagetian theory (1977; 1970) (Applefield, Huber, and Moallem, Dec 2000/Jan 2001) is

characteristic of endogenous constructivism, with dialectical constructivism following suit of social constructivism.

Exogenous Constructivism

The theorist Moshman hypothesized three distinct types of constructivism. Exogenous constructivism assumed that an external reality exists and that it is reconstructed as knowledge is formed (Applefield, Huber, and Moallem, Dec 2000/Jan 2001)). As a result, reflections of realist mental structures of the organized, existing world are representable. As explained by Applefield, Huber, and Moallem (Dec 2000/Jan 2001), based upon this representative constructivist view, attention is drawn to how the individual constructs schemata to explain the position of reality in his or her world-view based upon the “information processing conceptualizations of cognitive psychology” (p. 37).

Endogenous Constructivism

The endogenous stance to constructivism, also known as cognitive constructivism (Cobb, 1994; Moshman, 1982), is representative of a thorough focus upon the internalized, individual connections of knowledge primarily based upon the Piagetian theory (1977; 1970) (Applefield, Huber, and Moallem, Dec 2000/Jan 2001). Piagetian theory in this context “emphasizes individual knowledge construction stimulated by internal cognitive disequilibrium” (Applefield, Huber, and Moallem, Dec 2000/Jan 2001, p. 37). The disequilibrium is generated when reality is not coherent with sound logic in the explanation of both behaviors of individuals and objects as expected through sound scientific reasoning.

Dialectical Constructivism

Dialectical constructivism or social constructivism (Brown, Collins, and Duguid, 1989; Rogoff, 1990) bases its origin of knowledge construction on the “social intersection of people, interactions that involve sharing, comparing, and debating among learners and mentors” (Applefield, Huber, Moallem, Dec 2000/Jan 2001, p. 38). One stipulation added by the researcher is that the interactivity of the individuals requires an active process of exchange of information acquired by the learner. Dialectical constructivism is based on assumptions generated by Vygotsky’s Sociocultural Theory of Learning (1978) (Applefield, Huber, and Moallem, Dec 2000/Jan 2001, p. 38), which in itself accentuates supportive guidance by the mentors, establishing the presence of an apprentice learner “to achieve successively more complex skill, understanding, and ultimately independent competence” (Applefield, Huber, and Moallem, Dec 2000/Jan 2001, p. 38).

Contextualism

While the fundamental nature of social constructivism involves a collaboration between the learner and mentor, the process is in itself an active process filling some void of knowledge in “contrast to individual investigation[s] of cognitive constructivism” (Applefield, Huber, Moallem, Dec 2000/Jan 2001, p. 39). In addition to the context on which knowledge is constructed, a central tenet of constructivism is well documented in cognitive psychology involving contextualism. Contextualism holds that the importance of social constructivism is rooted in the importance of social exchanges as a means of promoting cognitive growth.

Radical Constructivism

The direction of constructivism illustrated by the research is a variation of radical constructivism as based on Piaget, Von Glasersfeld, Von Foerster, and retrospectively, Moore. The earliest reference to constructivist ideologies was the result of Piaget's referring to his work as constructivist, in addition to the work of Bruner's discovery learning. However, the basis of constructivism with regard to mathematics is its objective and logical nature outside the human mind (Stemhagen, 2004).

Piaget's Constructivism

According to Von Glasersfeld (1995), Piaget's constructivism is classified as a radical version of his genetic epistemology based on three assumptions. The first assumption is consistent with the fact that knowledge is constructed in the minds of the subjects, and regardless of intent, individuals must construct their knowledge based on their experiences (Von Glasersfeld, 1995). The second assumption is based on biological construction of the mind of humans, which are capable of acknowledging and organizing knowledge based on previous experiences. The third assumption, associated with mathematics, is the incorrect assumption that mathematics is fallibilist in nature. Even though a belief in a mathematical concept may be wrong, the individual may indeed be right to hold the incorrect belief even though it is impossible to create a proof which conclusively establishes the truth of the belief. For instance, the establishment of a proof based upon identity is precise in its logic. However, an individual may not accept the proof by identity in mathematics if the same concept under examination is unacceptable to the individual.

Von Glaserfeld's Radical Constructivism

According to Von Glasersfeld (1995), constructivism is concerned primarily with the concept “that knowledge, no matter how it be defined, is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience” (1995, p.1), illustrative of an empirical response. This approach to constructivism also incorporates a variant of constructivism of Piaget, not based upon the biological standard by which knowledge is solely acquired based upon experience, but on the logical formation of knowledge in conjunction with the experiences of individuals' development which assumes the logical basis of the knowledge conforms with the expectations of the individual.

The construction of knowledge of mathematics is purely logical in construct as constructivism is a perspective on knowledge and learning (Jaworski, Wood, and Dawson, 2005). As a proof is constructed to establish the basis of a fact, theorem, or axiom, the development of the proof occurs only once the logic of the material at hand is logically comprehensible based upon the previous bodies of knowledge regarding the subject being examined.

Von Foerster's Radical Constructivism

Von Foerster's constructivism is based upon two key epistemological components or themes, namely: “How we know what we know” (Segal, 2001, p. 5), and “an abiding concern for the present state of the world and its humanity” (Segal, 2001, p. 5). While the present state of the academic world is a concern for all involved, be it the student, the educators, those investing in educational institutions, or the parents of students, the

concern is centered around improving instruction and learning new material. However, addressing what we know with respect to mathematics may be approached by the development of axiomatic proofs and the phenomenological experience of students constructing the proofs.

According to Segal (2001), the dominant epistemology is concerned with how we view the world, and reality in particular. Of interest is how the individual views objective reality, and particularly how it exists independently of how it is viewed. In our case, the reality is based upon how the foundational principles of mathematics are viewed, and since we are viewing mathematics in the context of the construction of axiomatic proofs through the application of logic, it is questionable how the individual views the urgency of the construction of axiomatic proofs. As the phenomenological interpretation and expression of axiomatic proofs are of interest involving non-traditional female students in the study, the phenomenological implications are a valid case for investigation.

Moore's Radical Constructivism

Moore's stance on radical constructivism is viewed as an "explanatory principle for the process of knowing that has permeated mathematics education" (Hairston, 2003, p. iv) of the later 20th century. The pedagogical approach to teaching mathematics was fundamental with emphasis placed on the actual thought process instead of the rote memorization of mathematical material as addressed by Dewey in the 1940s. According to Whyburn (1970), the Moore method used an axiomatic treatment "to create in the student a spirit of self-confidence and pleasure in personal creative endeavor" (p. 352; as

cited by Hairston, 2003, p. 3). The phenomenological basis of his instruction concentrated on the experience generated in acknowledging mathematical concepts and was not concentrated purely upon the rote memorization of information.

Constructivist Application

The foundational methodology for educating college students studying mathematics in axiomatic proofs developed through logic is a modification of the constructivist principles of Von Foerster's twentieth century constructivism. The constructivism implied by the research is based upon the logical construction of mathematics with regard to the practical application of logic to enhance the construction of axiomatic mathematical proofs.

As axiomatic proofs are logical and methodical in their construction, approaching their construction as scalable is possible based on their validity and soundness to form a comprehensive argument, necessary in truth. The validity of an argument is based upon the idea that while the premises are true, it is impossible for the conclusion to be false. Likewise, the soundness of the arguments used in the construction of axiomatic proofs is rooted in the fact the proof is valid and all of the premises of the proof are true. With respect to the study, the premises are based loosely upon the statements of the students being interviewed, and the conclusions are based upon the same premises. As both are truly reflective of the phenomenological expressions of the interviewed students, both are considered necessarily true as long as *epoché* is correctly applied.

Employment of *Epoché*

As the phenomenological essence of an experience is under investigation in oral form for this study, the biases of the researcher negatively influence the data analysis. To accomplish the bracketing of biases, the researcher must properly employ the technique of *epoché* for the true essences of the experience to be understood and analyzed. The *epoché* process, or technique of employing *epoché* as defined by Moustakas (1994), occurs when a researcher, following a transcendental phenomenological approach, “engages in disciplined and systematic efforts to set aside prejudgments regarding the phenomenon being investigated” (p. 22).

The importance of employing *epoché* involves the differentiation between the knowledge and the opinion of the researcher. As the researcher attempts to bracket all personal prejudices from the study, the researcher creates an environment whereby the researcher is more receptive to the information being conveyed by the research participants, as well as eliminating any preconceived ideas based upon personal experience from the study. The principle of bracketing as outlined by Moustakas (1994) involves the incorporation of cognitive restraint, as demonstrated by Dennett and explained by Cerbone (2010), which Husserl called “transcendental-phenomenological reduction” (p. 22).

Axiomatic Validity

In the formation of axiomatic proofs, the premises are presented which employ scaffolding in order to lead up to the formation of a conclusion. The validity is ensured when the premises necessarily lead from one premise to the next premise before leading

to the formation of the conclusion. Each premise constitutes an axiom of the proof, and the collective set of premises and conclusions constitute the formation of an axiom system (Takeuti, 2013).

While axiom systems are primarily associated with the examination of set theory in mathematics, the same principles apply to the formation of arguments used to support qualitative arguments (Takeuti, 2013). In the case of the phenomenological, qualitative arguments presented during the research, each coded and categorized statement by the students interviewed provides the necessary support to the conclusions presented as a result of the research. While each statement is recorded, and categorized based upon the data in the statements, the validity of the statements is considered truly representative of the essences of the subject under study. In order to ensure this fact, the researcher must employ the phenomenological principle of *epoché* to help separate undesired influences on the collection and processing of the data.

Axiomatic Soundness

Soundness of an argument is based upon two conditions. First, the statements presented in the premises are true (Joseph, 2002). With respect to the collected statements by the students as a result of the research, the truthfulness of the statements is naturally ensured as the statements are encoded and categorized as directly recorded during the interviews. As the data collection and processing employ *epoché*, the statements are necessarily truthful. The second condition of the soundness of the qualitative argument established by the phenomenological examination is the fact that the conclusion is necessarily true and under no circumstance may be false (Joseph, 2002).

The conclusion generated as a result of the phenomenological research is also necessarily true as it is formed as a result of the data collected during the research.

In the formation of an argument, if the argument is valid, the chance occurrence of the conclusion being false is possible upon only two conditions. First, if the statements made in the premises are not conclusively true, or if in some degree, the argument is ambiguous, the premises may be construed as either weak or false by force. Secondly, if the conclusion does not of necessity follow from the truthfulness of the premises, the conclusion may be construed as *non-sequitur*, and as such, incorrect (Brenner, 1993). As the statements forming the premises are true by necessity, as they are true reflections of the experiences of the students, the conclusions based on the premises are necessarily true as they are considered unfiltered due to the application of *epoché*.

Phenomenological Implication of Proofs

The logic of constructing proofs for mathematics students creates an environment of anxiety (Alsup, 1995; Tran, 2007); the application of reason is palpable for all mathematics students. The essences of reason are communicable through phenomenological interviews, expressing the necessity of reason as a key component of not only the effectiveness of the educational reform, but of the accurate expression of mathematics. Employing *epoché* is critical in the succinct examination of the topic in order to avoid any undue influence in expressing the phenomenological essences or the interpretations of the same during analysis.

Phenomenological Purpose

The purpose of the study is to examine the shared experiences of non-traditional female students which develop as the result of studying collegiate mathematics. As previously outlined, the experiences a student may develop as the result of studying collegiate mathematics, and those of the non-traditional female students are unique to themselves alone with a certain degree of overlap. By understanding these shared experiences, the essences generated by the students provide valuable feedback to the educator with the intention of personalizing instruction in mathematics in order for all students to better learn and assimilate the material.

As the shared experiences of non-traditional female students examining the study of collegiate mathematics may be influenced due to the heavy reliance on the formation of axiomatic proofs, the employment of *epoché* is critical in accurately categorizing the shared experiences, as well as the formation of any arguments for or against the construction of the same axiomatic proofs. As the phenomenological examination of the students is truly reflective of the students' experiences, some similarities and differences are expected. In order for the study to be consequential, it is necessary to examine both the similarities and the differences based upon the categorizing of the statements from all the students involved in the study.

Phenomenological Reductionism

The phenomenological reductionism of summary judgments of accessing and categorizing phenomena as explained by others requires an intrinsic separation or bracketing of meaning which as attributed to Husserl (1982 [1913]) is formally known as

epoché. The purpose of phenomenological reductionism, or *epoché*, is to separate all prejudices and standards by which an individual operates in order to remain more objective when assessing, categorizing, and coding phenomenological essences through statements of those being interviewed (Moustakas, 1994). Additionally, by separating the prejudices a researcher may have, the statements of the participants are interpreted in their truest form without distorting or implying standards not intentionally implied by the participants.

The constructivist principles also apply to the distorting of statements expressed by the research participants when phenomenological reductionism is not applied. By distorting one statement, the analysis of all of the statements begins to fit into the interpretation of the researcher and not what was intended by the research participants. It is therefore imperative that the reductionism of researcher bias be addressed before any data are collected as well as during the data collection, the analysis phase, as well as the reporting phase.

Before the actual full development of phenomenology as a serious field of study in the 20th century, the works of William James established that the pragmatic establishment of empirical truths could be established as a form of radical empiricism. According to Hakim (2001), the truths established in James's empiricism and later ratified through phenomenology were based upon psychological premises. To James, the "touchstone of truth" (Hakim, 2001, p. 540) is experience. As the critical examination of experiences are key to the subjective understanding of the individual, particularly through

the lens of phenomenology, it is only through experience that one may concretely establish or verify any position.

Depending upon the author, the definition of phenomenology varies with an increased response to context. As defined by Schutz (1967), a study organized on phenomenology seeks a view of the experience of the participant from the participant's point of view establishing a "subjective understanding" (Seidman, 2013, p. 17). Just as reflective thinking, per Dewey (1933) and explained by King, Wood and Mines (1990), as "the careful collection and evaluation of evidence leading to a conclusion, should be a central aim of education" (p. 1), the critical thinking involved in the study of mathematics requires the application of abstract thought, in parallel with a constructivist perspective consist with McPeck's claim that critical thinking is specific to particular disciplines such as mathematics (Mason, 2007). Likewise, the definition of phenomenology per Hegel, as expressed by Schmitt (2006), involves "the science in which we come to know mind as it is in itself through the study of the ways in which it appears to us" (p. 278).

In comparison, Heidegger in 1927 addressed phenomenology as the expression of the experience contingent upon the language used in its expression; the limit of language thereby creates what is describable as a probable or relative understanding of the phenomenological and existentialist analysis of human experience (Tarnas, 1991). As defined by Schutz (1967), the only way for an individual to have a true understanding of a participant's experience is to be in possess of their consciousness, which would require that the researcher become the individual. Additionally, it is impossible for a person to critically examine a phenomenon while it is occurring, as the process would change the

interpretation of the same. As expressed by Manen and Manen (1990), phenomenological reflection is not introspective, as is often the case with the examination of philosophical doctrine, but entirely retrospective.

The restrictive nature of language to express a phenomenon is contingent upon premise; as a proposition can explain a situation, the definition of the terminology used in the proposition involves some sense of accommodation. As expressed by Copleston (1993), defining man based upon certain pre-established characteristics assumes everyone possesses the same characteristics. However, in the context of the study, declaring that each female student interviewed during the research may possess common characteristics is grossly restrictive in a literary context. The common thread expressed in the research may find commonalities, although it is not possible to accommodate every case, regardless of the intention of the researcher. In the context of Heidegger (1927), the accommodation assumes expressing the commonalities present in every case.

Transcendental Phenomenology

As defined by Seidman (2013), the goal of researchers employing a phenomenology approach to a study attempts to come as close as possible to a true understanding of the experience. While Schutz (1967) expressed, and Manen and Manen (1990) reiterated, the phenomenologist attempts to develop a “subjective understanding” (Seidman, 2013, p. 17) of the experience, it is through reflection that the participant is capable of reconstructing “the constitutive elements of lived experience” with the same constitutive elements establishing a “phenomen[on]” (Schultz, 1967; as cited by Seidman, 2013, p. 17). However, transcendental phenomenology, per Moustakas (1994)

refers to the scientific study “of the appearance of things, of phenomena just as we see them as they appear to us in consciousness” (p. 49).

As expressed by Murphy (1963), while reality may or may not be transcendental, the principles of transcendental phenomenology are rooted in the notion that “reality has no meaning to us or ‘sense’ itself as it manifests itself or ‘appears’ in consciousness” (p. 1). While the concept of consciousness is suggestive of a juxtaposition notion, that the student is an empty vessel into which knowledge can be delivered, the constructivist principles outlined by Bruner impress upon us that learning is an active event (Culatta, 2016).

Transcendental State

For a transcendental state to exist, it is necessary for the knowledge under examination to exist based upon sufficiently conclusive grounds. As explained by Moustakas (1994), the first condition which must be enforced is the presupposition “that one can achieve a pure and absolute transcendental ego, a completely unbiased and presuppositionless state” (p. 60). The establishment of a “pure and absolute transcendental ego” (Moustakas, 1994, p. 60) is purely contingent on the use of *epoché* to bracket all biases and preconditioned responses to stimuli. While the technique would not incorporate the elimination of egotistical justification of a stance, it would require the researcher to establish a point whereby personal judgments and preferences are kept in check to establish a neutral ground upon which the research may be conducted.

The second condition involving the establishment of a transcendental state during the research phase incorporates the fact that self-evidence, in the words of Moustakas

(1994), is *apodictic* (p. 61). As a person interprets his or her own thought processes and impressions of a situation as being objectively truthful of the individual, the expressions of these thought processes are thought to be accurate, regardless of how they are interpreted. However, the interpretation of the processes leaves a translational gap wherein the researcher attempts to associate with his or her own experiences, thus establishing the subjective understanding.

The third conditional to the establishment of a transcendental state is derived from the fact that just as the expression of phenomenological research is restricted to a first-person experience, the experience which is restricted to empirical gathering of information through the senses is consistent with empiricism. While philosophers such as Descartes viewed the only true way of ensuring rationalist reality was based upon his “*Cognito, ergo sum*” (I think, therefore I am) (1641), the experiences of the individual are unique to the individual himself or herself, and as such only considered objective in the mind of the individual.

Transcendental Idealism

It is questionable how phenomenology differs from the other significant philosophical school of thought, known as idealism. Phenomenology as a philosophical doctrine is clearly different from that of idealism, which holds steadfast a denial of the commonsense realist view of material things as we perceive them being independent of ourselves (Acton, 2006). However, the study of phenomenology does parallel the study of the philosophy of mind based upon its curtail about what constitutes reality in the mind of the individual. Additionally, as the study of phenomenology incorporates the

paradigms of rationalism and empiricism, it is questionable how exactly the field of phenomenology may be approached in differentiation from those two branches of philosophy, particularly with regard to the implied adherence of phenomenology as a concrete branch of science.

The view of Kantian transcendental idealism, per Allison (2004), is in actuality an anti-idealistic approach, often based upon the interpretation of the “two object” or “two-world” view (p. 3). According to Allison (2004), many critics of the concept of transcendental idealism view it as a “metaphysical theory that affirms the uncognizability of the ‘real’ (things in themselves) and relegates cognition to the purely subjective realm of representations (appearances)” (p. 4). This interpretive stance parallels the consensus of ideals surrounding the study of phenomenology on the grounds of Husserl. Likewise, the interpretation combines what Allison (2004) views as a “phenomenologic, or essentially, Berkeleian account of what is experienced by the mind, and therefore cognizable, namely its own representations, with the postulation of an additional set of entities, which in terms of the very theory, are uncognizable” (p. 4; citing Allison, 1983).

Conclusion

It is well documented what portion of the study body comprises non-traditional female students and the inability of the same group to achieve proficiency in the study of mathematics by not “meeting their potential in mathematics” (Silliman-Karp, 1988, p. 1) based upon the student’s sense of efficacy (Bandura, 1986). Non-traditional female students, according to the National Center for Education Statistics (1995c; 2000) are represented by students who enter undergraduate studies starting at the age of 25 years.

As President Obama (2014) called for an increase in the number of STEM graduates by 100,000 in the 21st century, the cost of the same inability to achieve equality in the study of mathematics has a negative impact on the cost of tuition (Kra, 2013) as well as a form of inequality in the representation of graduates of STEM programs (Moakler and Kim, 2015).

A possible source of the failure of female students meeting the balance in the presentation of STEM program graduates may be attributed to outdated constructivist ideologies as criticized by Dewey in the 20th century. Influenced by the social constructivist ideologies of Dewey, Piaget, and Vygotsky, constructivist theorists such as Bruner and Moshman have attempted to address the inequality based upon the principles of motivation. The theorist Knowles addressed the study body consisting of adult students based upon intrinsic and extrinsic motivations. As motivations change from extrinsic in younger adult learners to mostly intrinsic in older adult students, the lack of representation of adults of the age of 60 and older as noted by Knowles creates a clear separation of learning capabilities which conflict with the general belief of educators that all students are capable of learning.

A common finding among non-traditional female students studying mathematics is the development of math anxiety. Often brought about by bad experiences early in secondary education, students who develop math anxiety readily tend to avoid taking math courses which may be particularly rigorous. As a result, students who exhibit math anxiety are more prone to avoiding highly technical degree majors which require a heavy reliance upon advanced mathematics, such as those in STEM programs. While math

anxiety may develop in anyone, those particularly vulnerable to the condition may describe their mathematical capabilities as similar to the phrase, “they ‘just can't do math’” (Gonske, 2002, p. 1).

CHAPTER 3. METHODOLOGY

Research Questions

As the research involves female non-traditional students, the selection of the same is outlined specifically in both the sample being derived from the entire student body from Purdue North Central and Purdue Calumet campuses which are now collectively referred to as Purdue University Northwest.

Phenomenological Qualitative Research Question

How do lived experiences prepare non-traditional female students for undergraduate-level mathematics courses?

Sub-questions

What commonalities exist in the described lived experiences of non-traditional female students studying mathematics?

What differences exist in the described lived experiences of non-traditional female students studying mathematics?

The purpose of this phenomenological qualitative dissertation is an examination of the essences of female, undergraduate non-traditional students studying mathematics at either the Purdue University North Central or Purdue University Calumet campus. The methodology employed in the research is based on an interpretation of phenomenology by Merleau-Ponty (1962), who stated, “Phenomenology is the study of essences; and according to it, all problems amount to finding definitions of essences: the essence of perception, or the essence of consciousness, for example” (p. vii). Thus, of interest to the research is how the mathematics student views the significance of studying mathematics

in relative terms of her own understanding. These individualized expressions of experiences make the examination of the essences of non-traditional female students studying mathematical beneficial to the researcher.

In this type of qualitative methodology, the researcher reduces the experiences to a central meaning or the essence of the experience of studying undergraduate mathematics. The conformity of experience through mathematics ensures that the abstraction of mathematics is comprehensible to students whose cognitive development allots for the study of the same abstraction in mathematics. The participant disclosures express the fact that the experiences generated as a result of studying mathematics have no intrinsic truth value, thereby emphasizing the point there are no right or wrong responses.

Phenomenology as it relates to the lived experiences of non-traditional female students studying collegiate mathematics is of vital importance to the researcher in understanding what difficulties the students experience in studying mathematics. While the experiences in studying collegiate mathematics are different for every student, the lived experiences of non-traditional female student provide feedback into the successes and difficulties these students endure firsthand, thus providing feedback on how to possibly improve math instruction for them. As some of the lived experiences of non-traditional female students are unique to those students, and by understanding how other lived experiences influence the study of mathematics, the educators will find constructive means by which to help students make the associations with the abstractions of studying mathematics.

The subjective nature of expressing and interpreting the essences of a phenomenon leads to the categorizing or coding of information gathered from the participants under examination to find a synthesis of information which may be expressed showing a shared experience. While the experience of mathematics may be categorized in similar collections of perceptions, particularly in the rationalization of mathematics, the subjective nature again requires the application of bracketing or *epoché* in order to avoid influencing the expression of the same. The desired effect is to organize the results without influencing the conclusions phenomenologically, thus tainting the results or findings.

Participant Disclosures

Due to the structure of the research design, students who elect to participate in the study must complete a general registration form that explains the purpose of the research and the methodology for conducting the research. In addition, the disclosure form explains that the information gathered may not be distributed to others during or following the research, and the explanation that the information gathered will be immediately destroyed upon the conclusion of the research and completion of the dissertation. Additionally, each student may elect to leave the study at any time without any disciplinary action by the university, and any information gathered from the student is immediately destroyed. Finally, the students electing to participate in the research will be required to complete a release form which permits the very limited use of the findings of the research while entirely providing anonymity for the students participating in the research.

In order to ensure the unbiased selection of participants in the study the associated campuses will contact female non-traditional undergraduate students through email to ensure an additional layer of safety, and by posting participation notices on campus in order to randomize the selection of participants in the study. Knowledge of the individuals electing to participate in the study is restricted until the minimum number of students has been determined in order to avoid the influencing of the selection.

Sample

The sample of the student body includes female students at either the Purdue University North Central campus or Purdue University Calumet campus consisting of non-traditional students. According to the National Center for Education Statistics (n.d.), the traditional age for students enrolling in college is between 18 to 24 (citing Hurtado, Kurotsuchi, and Sharp, 1996). The purpose of selection of age for inclusion in the study is to ensure a heterogeneous body of students. In the study, non-traditional female students include those who entered college at the age of 25 or older. Additionally, the students are taking a mathematics course or have completed the same.

Setting

The setting in which the research is conducted will include the university campuses of the Purdue University system. The selection of the Purdue University system of campuses for participation in the study is due to its thorough undergraduate and graduate-level mathematics programs. Additionally, the Purdue University system of campuses was also selected due to the large number of non-traditional students currently studying advanced mathematics as of the 2015-2016 academic school year.

Data Collection

Data collected as a result of the research include responses to questions posed in a series of two interviews. The first interview seeks to acquire background demographic information as well participants' general responses about the practicality and significance of the study of mathematics. The second interview seeks to acquire the essences of each student in studying mathematics with close attention to the self-perceived importance of studying mathematics. All interviews are recorded by tape media for later categorization and coding to be conducted during the analysis phase.

Expression of Phenomenon as Statistical Laws

The observations made because of the research present, in the loosest context, a statistical law. Unlike universal laws such as that of gravity, which are necessarily true for all worlds, statistical laws provide explanations with a certain degree of probability. The observations made, per Carnap (1995), "in everyday life as well as more systematic observations of science reveal certain repetitions or regularities in the world" (p. 3). The explanations provided by statistical laws provide how a fact, or in our case the phenomenon of personal opinions and prejudices regarding the study of mathematics, may be explained. The repetitions, as expressed in general by Carnap (1995), were initially expressed through a pre-course questionnaire in 2012, as well as three recent impromptu interviews and the interviews conducted as a direct result of the research.

A common point of repetition that may be identified involves the fact that mathematics, beyond basic mathematics, becomes more involved with using formulas and complication techniques necessary to solve mathematics problems. For instance,

mathematical ability, as stated by Kyttälä & Lehto, “consists of both conceptual and procedural competencies which are supported by different cognitive systems, such as working memory and its subcomponents” (2008, p. 77; Geary, 2004). Bradford (2016) expressed the fact that if formulas and complex mathematical procedures are not regularly used in one’s profession, the chances of recalling the procedures become problematic (personal communication, 2016).

Treatment/Intervention

The interview processes followed during the research include those outlined by Moussakas’ (1994) *Phenomenological Research* text, particularly involving transcendental phenomenology as well as the procedures and guidelines outlined by Seidman’s (2013) *Interviewing as Qualitative Research* text as treatments. As every statement from a research participant is reflective of the thought processes of the participant, “every word that people use in telling their stories is a microcosm of their consciousness” (Vygotsky, 1987, pp. 236-237; as cited by Seidman, 2013, p. 7). The consciousness of the individual is a reflective expression of personality, education, and qualities of self-reflection. The ability of an individual to express himself or herself, and in particular the essences of experience, is contingent upon the individual’s ability to communicate the same.

The first stage of the research involves reaching out to non-traditional female students at either the Purdue University North Central or Calumet campus. Contact will be made by the administration through emailing the appropriate body of students in order to insure a degree of separation for safety. The email addresses will be known only by

the administrations of the respective campuses with first contact with the individuals being made to the participants with instructions on how the participants may make contact with the researcher. All communications with the research participants are encoded with the identifier illustrated.

Participant Number # – Month (1-12) – Year – Campus (NC or Cal)

Example: Participant # 06 - 03 - 2016 - NC

Additionally, the participant will only be contacted either by phone and/or email upon request. Each participant is unknown to the other participants unless the participants seek out other participants on their campus.

The second stage of the research involves the distribution of Participant Participation Form as illustrated in Appendix A, and all associated declarations expressing the purpose of the research. Upon return of the participation form, the research participant will be contacted by phone and email to schedule a convenient time for all parties to meet and conduct the first phase of interviews.

The third stage of the research involves conducting two sets of interviews, ranging from 30 to 60 minutes, separated by a minimum of two weeks in order to analyze and code the interview. The example of the first set of interview questions is illustrated in Appendix B. The second set of interviews will also last between 30 minutes to 60 minutes in order to clarify any statements expressed during the first interview. A second phase of coding and analysis is conducted in order properly to summarize and categorize the essences of the participants regarding the study of undergraduate high-level mathematics.

The fourth stage of the research involves analyzing and coding the interviews from the third stage of the research, seeking to identify whether any shared experiences or essences were present. The fourth stage also involves organizing and representing all findings in a format in which anonymity is ensured. Upon completion of the research, a copy of the research findings is presented to the participants who wish to receive a copy.

Data Analysis

The data analysis phase includes coding responses to the questions posed in Appendix B (basic categorizing questions) followed two weeks later by following analysis and coding the essences of studying mathematics as a non-traditional undergraduate student. The purpose of a two-week delay with the follow-up interviews is to ensure that the responses are not necessarily repetitions of the first interviews, and the formation of follow-up questions as a result of the categorization of data from the first phase of interviews.

Validity and Reliability

Key to ethically productive data collection and analysis are the principles of the validity of data collection, as reported by Wood (2014), ensuring the accuracy of the data collected are representative of the phenomenon under consideration, as well as ensuring the data collected are reliable and truly representative of findings of the phenomenon with the condition the results are repeatable under similar circumstances of other follow-up studies. To this mean, in order to ensure both validity and reliability are met, Merriam (2009) outlines several key considerations to ensure ethical demands.

The key to ensuring validity and reliability from interviews conducted as part of the phenomenological study involves acknowledging self-concept (Gall, Gall, and Borg (2007). The concept of self-concept, according to Gall, Gall, and Borg (2007), is defined as “the set of cognitions and feelings that each individual has about himself or herself” (p. 219). The researcher may wish to acknowledge the fact that the understanding an individual has with regards to his or her own mental and physical state is objective in nature; however, any interpretation of what is said by the individual as part of an interview or questionnaire is interpretable purely on subjective grounds.

While Merriam (2009) identified eight key strategies deployable to ensure validity and reliability of a study, with triangulation, in Merriam’s terms, perhaps the most critical (p. 229). In academia, methodology employed involves the use of multiple scholarly sources when performing research with the sole intention of identifying and discharging any potential outliers in the data. By using multiple sources, the researcher may eliminate, or at least limit, any erroneously reported data, which may have been conducted and reported from being used as a scholarly source contributing or possibly confounding research. In addition, by using multiple instruments and data collection methods, the researcher(s) may ensure the findings obtained are unbiased because the research are truly representative of the phenomenon under investigation, and not confounded by outside influences.

Consistency is a considerable a critical concern of researchers who seek to obtain data from any research participant. With the ethical treatment of research participants an utmost concern to any researcher, proper documentation and consideration must be taken

into consideration to ensure the research participants are not harmed in any foreseeable and preventable manner. This founding upon ethical grounds is utilized in order to not only ensure the absolute safety for all involved, but to also ensure the ethical grounds of the investigation have the best interests of the individuals in mind.

With respect to data collection and analysis, the meanings of data collected through qualitative methodology may not be explicitly clear in pointing out the phenomenon under consideration, possibly due to either ambiguity on part of the responses of the research participants through questionnaires and/or interviews, or possibly due to the fault of the instructions provided with instrumentation. A popular technique used to limit or avoid ambiguity incorporating subjective responses involves the elimination of any slang or regionally specific terminology from instruments such as interview questions. It is highly advisable that the researchers use active voice in constructing instruments as well as formulating questions, which encourages the use of first person pronouns by the research participants when they construct their responses. The goal of this action is to ensure the participants of the study take first-hand responsibility for their responses, and to ensure the responses are not being curtailed from outside influences. Additionally, it is advisable to encourage the research participants to write in free form when developing responses incorporating opinions, and carefully directed responses when a dichotomy is expected to exist in the responses.

During data collection, it is advised the researcher does not attempt to collect data at times when it is necessarily only convenient for himself or herself. It is important to ensure the data is collected where and when it is convenient for the participants to ensure

the data is not rushed in the collection, and that participant is most comfortable with providing their responses. It is also advisable the researcher does not simply attempt to collect data that necessarily fit their theory, because the researcher may collect data which contradict his or her hypothesis. The researcher must see any information which does not necessarily support the hypothesis as evidence, which may be used to fine-tune the hypothesis. The researcher is strongly advised not to collect the minimal amount of data from his or her research in the event some of the information is not usable due to either retraction of findings or withdrawal of the research participant from the study. In terms used by Merriam (2009), the data must become “saturated” (p. 229).

During the maintenance of all ethical standards and commitments during the research design, implementation, collection, and publication of findings the researcher must remain critically self-reflective with regard to “assumptions, worldview, biases, [and] theoretical orientation” (Merriam, 2009, p. 229). Ethical dilemmas may readily develop during the research which may require the researcher to critically examine his or her research methodology to the extent it may be necessary to modify or retract any one or all of the steps of data collection. It may also be necessary to reselect one or more research participants possibly due to cultural or ethical grounds not foreseen during the research design stage. Finally, research design modification may be necessary because of peer review recommendations or requirements in order to comply with any ethical demands.

According to Merriam (2009), the researcher must provide enough descriptive information to the study “to contextualize the study such that readers will be able to

determine the extent to which their situations match the research context” (p. 229). The researcher must also explain how the findings of the study may apply to the research participants as well as to others possibly in a similar situation through the process of transferability.

Instrument Validation

The instruments used during the research constitute a questionnaire as illustrated in Appendix B for the first phase of interviews, and a series of questions dynamically generated in response to those questions posed during the first phase of interviews. As no instrument is employed in the data collection other than interview questions, the validation is completed by the Dissertation Chair or an appointee to ensure the questions are unbiased and gender neutral.

Research Question Alignment

As the constructivist paradigm employed in the study incorporates an ontological and epistemological investigation, as explained by Bloomberg & Volpe (2012) and Saldaña (2013), the research questions in the study align themselves with the nature of the participants’ realities. As explained by Kemp (2012), researchers who endeavor to address research from a constructivist platform are faced with the concern of how to address the data collection and analysis whereby all matters related to the study acknowledge constructivist principles and thought.

As the study is concerned with the transcendental aspect of phenomenology, the study is primarily concerned with the “systematic and disciplined methodology for deviation of knowledge” (Moustakas, 1994, p. 45), whereby the logical assumption is

made that only the data available to the consciousness deserves merit, and as such only things we know for certain appear before us in our consciousness. This very fact, according to Moustakas (1994), is what ensures its objectivity, thus ensuring the expressions of the experiences of the research subjects are classifiable as objective from an emic perspective even when the research at best can only assume a subjective understanding.

The epistemological aspect of the transcendental phenomenological investigation is rooted in the notion that the facts under investigation are purely constructed in response to empirical data from two perspectives. The first perspective approaches the phenomenological expression of experiences from the understanding that “the mind identifies objects as indicators of categories rather than raw sensory data” (Rudestam and Newton, 2015, p. 43). The second perspective approaches the study of phenomenology on “‘existential’ or ‘interpretive’” grounds (Rudestam and Newton, 2015, p. 43). The interpretive approach is in response to Heidegger’s existential contributions which were more interested “in the uniqueness of individuals rather than the classification schemes found across people” (Rudestam and Newton, 2015, p. 43), such as how different people understand and give meaning by way of association with similar life events which they themselves have experienced.

Ethical Considerations

The first and perhaps the most crucial ethical consideration related to the study is ensuring the information regarding the students is secured so that the information may not be accessed online or contain any identifiable information provided by the

participants. As previously outlined under Data Collection, the identification of students in the study is contingent upon the use of the identification code to ensure anonymity of all students involved in the research. In order to illustrate exactly how the findings of the California Critical Thinking Skills Test are presented to the students, the author of the dissertation will also complete the assessments and use his results in order to properly illustrate not only the findings but the formatting generated.

In order additionally to ensure the data collected are protected against accidental exposure, the identities of the research participants will only be known to the researcher and any overseeing body when absolutely necessary. Additionally, the data collected will be stored offline in a secure structure to ensure the information is not accessible to anyone other than the researcher. Any communications to the students participating in the research will involve identifying the student by the code that is generated to represent the student and a written copy of the final report will be provided to each research participant for her own use.

Conclusion

The methodology employed during the study in the collection of data, as a result of the interviews, addresses the ethical considerations of the random selection of students who qualify as non-traditional female. Additionally, even though the selection of students for the study is dependent upon the constraints that the students are both females and qualify as non-traditional, the selection is randomized as the selection of the students is determined by the staff of either Purdue University North Central or Purdue University Calumet which collectively are referred to as Purdue University Northwest. To ensure

anonymity of the students, the notification of the study and communication with the participants is conducted by the staff of each campus of Purdue University Northwest, ensuring that the privacy of each student is ensured. Finally, to ensure safety for all the students involved in the study, interviews are conducted entirely on the campuses of Purdue University Northwest in locations selected by each campus.

CHAPTER 4. RESULTS

Introduction

The use of phenomenology as a means of investigating the interpretations and opinions of the participants is rooted in the real-world assessment of phenomena by understanding “the basic structures of human experience and understanding from a first person point of view” (Merleau-Ponty, 2014, p. viii). The first-person examination of experiences through phenomenology is a clear deviation from the third-person “perspective that tends to dominate scientific knowledge and common sense” (Merleau-Ponty, 2014, p. viii). As a result, phenomenology is considered both a philosophy and a rigorous reflective methodology according to Morrissey and Barber (2014), as phenomenology as viewed by Husserl was concerned primarily with the world as it was experienced not by society as a whole but by the subject from the first-person point of view.

The qualitative basis of the study entails addressing “the nature of participants’ realities” (Saldaña, 2013, p. 61). Of interest to the study is how the participants view their roles in the study of mathematics, particularly in relation to studying which is directly related to the teaching of mathematics in an educational setting. Accordingly, the orientation of the encoding used in the study assists the researcher in identifying common themes or categorical discrepancies which arise from the data collected.

Emotion Encoding

Typically, emotion encoding is open to magnitude quantitative measurements in mixed methods assessments (Saldaña, 2013). Mixed methods assessments entail a combination of both statistical analysis based upon common categories of quantifiable data in addition to qualitative assessments in order to determine commonalities (Saldaña, 2013). Quantifiable data typically have a numerical component, either directly through the use of numbers or the use of categories upon which the data may be sorted. On the other hand, qualitative data, composed of a narrative component upon which inferences may be drawn, comprise the remaining half of mixed methods research (Saldaña, 2013). However, in the case of the research presented herein the basis of the ontological orientation dictates the use of emotion encoding as the expressions of the participants may clearly be understood as emotional due to the nature of the interview questions' neutral orientation. Additionally, as the orientation of the subject being examined is rooted in the constructivist interpretation of mathematical knowledge, the ontological basis dictates the encoding of the responses in a similar fashion as the actual responses. As the responses are clearly illustrative of the perceptions and interpretations of the participants, so is the encoding basis of the same responses.

***In Vivo* Encoding**

In vivo encoding is commonly used when there is a desire to prioritize and truly represent the voice of the participant (Saldaña, 2013). In the case of the study, the voices of the participants are important for the categorization of common themes and phrases which represent the key responses to the interview questions. Additionally, to the

participants their experiences and any deduced essences of the same experiences are deemed valid for the sake of argumentation. This is due to the fact that the conclusions generated from the expression of the experiences are true out of necessity, due to their objective nature in the form of premises, and it is impossible for the conclusions generated from the same to be false.

Descriptive Encoding

The grounds upon which descriptive encoding is employed in the qualitative research incorporates a post-positivism approach, which according to Gall, Gall, and Borg (2007), is an epistemological consideration whereby one “assumes an objective reality, but that this objective reality can only be known imperfectly” (p. 16). Just as it is impossible to develop a completely objective understanding of the phenomenological interpretations of participant’s responses to interviews, even using *epoché*, a theoretical gap exists in the interpretation, the verbal justification and assumptions are contingent upon the use of language (Moustakas, 1994).

Preliminary Interviews Directing Research

Before conducting the research presented herein, a questionnaire was distributed to students in an undergraduate statistics course offered through Purdue University in August 2012 and January 2013 as part of a pre-course inquiry seeking to understand the opinions of the students regarding their experiences and opinions involving studying mathematics. Davidson (2013) expressed that she, a female non-traditional student, had bad experiences in studying mathematics in high school and thus had a great deal of

apprehension and anxiety in studying mathematics as part of her college degree curriculum in Communications.

Two impromptu inquiries were conducted before the preparation of this dissertation with similar declarations which naturally lead to the direction presented in the research. In the first case, bad experiences in secondary education created a psychological barrier in which the individual developed a profound hatred for the study of mathematics (Wood, 2015). As reiterated by Quan (2015), Perry (2004) asserted “the majority of college students exhibit feelings of fear and discomfort when put into situations that require the use of mathematics” (p. 8). This fact is substantiated by research findings (Quan, 2015; Van Wagoner, 2015; Rawley, 2007) where the psychological barrier may be judged in summary as a phenomenon labeled collectively as mathematical anxiety (Quan, 2015).

According to Richardson and Suinn (1972), and summarized by Quan (2015), mathematical anxiety may be described as “tension and angst that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (p. 1). Wood (personal communication, 2015) expressed her psychological trauma regarding the study of mathematics developed in 7th grade; the trauma existed even into the collegiate setting in preparation for entering nursing.

In the second case the individual stated that perhaps the greatest obstacle which prevents women from typically pursuing careers in mathematics is that of fear (Bradford, personal communication, 2016; Geist, 2010). The fear, as explained by Bradford

(personal communication, 2016), is possibly derived from the heavy reliance on formulas necessary successfully to study advanced mathematics, as well as the multitude of techniques necessary to solve even the more moderate mathematical problems.

Bradford (personal communication, 2016) expressed that, as formulas are not readily used on a regular basis unless they are part of one's career, collectively they are very difficult to retain. Accordingly, Bradford (2016) expressed that, as some mathematics is necessary in everyday life for simple tasks such as maintaining a banking account and building structures, formulas that are taught regularly in mathematics may not be retained readily; a fact substantiated by Levine (1995). Both individuals (Wood, personal communication, 2015; Bradford, personal communication, 2016) expressed the opinion that the study of mathematics is dependent upon the fact the individual is either good at math, or he/she is not. Based upon the initial impromptu interviews and in-course inquiry from 2013, if the data are consistent, a sizable portion of the female student body may have the same general mathematical anxiety as expressed by Davison (2013), Wood (2015), and Bradford (2016).

Interview Question Organization

The general structure of the interview questions is presented in Appendix B with each section defined in greater detail here.

Demographics and Categorizing

The first section of the interview form entails the collection of the name of the individual, age, maximum level of mathematics completed, and confirms that the participant is age 25 or over. The second section of questions is used to categorize the

participants based upon full- or part-time basis in school, the maximum level of mathematics studied at Purdue University, and her declared major. Following the completion of the demographics and categorization sections of the interview questions, the participant was given a unique identifier as expressed in Chapter 3.

Emotional Association of Mathematics

The third section of the interview questions is oriented to examining the emotional association the participants have with studying mathematics and what they believe are the common feelings of other students studying mathematics. As explained by Gonske (2002), students tend to fall between two extremes: Either the students feel they are successful in the use and manipulation of mathematics or the students feel they are inadequate in some way to study mathematics as summarized by “math anxiety” (p. 1). In this context, “math anxiety” (Gonske, 2002, p. 1) often leads students who view their abilities in studying mathematics as limited to avoid taking prerequisite mathematics courses in high school, thus leading the student to be unprepared for the rigors of studying collegiate mathematics when necessary.

Opinions of Mathematical Education

The fourth section of the interview questions is oriented to examining the opinions the participants have regarding the relevance of mathematics, and what they feel is a necessary ending point of studying mathematics where it is sufficient for the general population. Finally, the participants were asked to assume the role of graduate-level mathematics students. The participants were then asked at what point would they feel they were adequately prepared to teach mathematics to others.

Theoretical Perspective

The fifth section of the interview questions is theoretically oriented. The participant was asked to assume the perspective of a mathematics teacher or professor, and to express what they felt was critical for the public to know regarding the study and use of mathematics. The question creates an environment in which the phenomenological expression of the answer sheds light into the perspective and expectations regarding the study of mathematics.

Opinions Regarding Mathematics

The primary question of interest is how the individual would describe the importance or lack of importance of studying mathematics. The preliminary results of the subjects interviewed before the research are expressed later in Chapter 5, showing a consistency regarding the possible prejudices and anxieties associated with the study of mathematics. The questions posed in the research seek to determine if the same prejudices and anxieties are present among the women interviewed during the research. An additional follow-up question was posed asking if the interviewed individual were to assume for a moment that studying mathematics serves a purpose, how she would describe the purpose.

Participant Responses

The purposes of the questions seek to understand the individual's opinions and the essences of the experiences regarding the study of mathematics. Additionally, as the responses in summary express these opinions and essences, the responses are usable as a means of possibly expressing the data as a statistical law. The responses are based upon

the interview questions as expressed in Appendix C. All responses are organized by category and question number form in tables located in Appendixes D through H.

Participant # 01 - 10 - 2016 – NC

The first participant is a 39-year-old full-time undergraduate student at Purdue University Northwest North Central Campus with a declared major of Early Childhood Education.

Emotional Association of Mathematics

When the participant was asked about her initial impression of mathematics she expressed that it generates a feeling of intimidation brought on by bad experiences in studying the subject in high school, which led to the tendency to avoid mathematics in its entirety until the time of her first-degree program, when she could no longer avoid the subject. Additionally, the mathematics course she stated that she had completed was traditionally associated with an easier curriculum as opposed to those associated with the hard sciences. When asked if the participant's initial impression has changed since she took her first collegiate-level mathematics course, the participant responded she now feels more confident and comfortable in studying mathematics and no longer feels a mental "block" exists regarding the subject.

When the participant was asked what she felt might be the impression of others studying mathematics, she expressed what tends to be a common theme of some intimidation of others regarding the study of the subject. When the participant was asked, what was the relevancy of studying mathematics, she responded, "I believe that

mathematics is very relevant not only to my future profession of being an educator but also just in ‘everyday life.’”

Opinions of Mathematical Education

When the participant was asked what aspect of mathematics should be investigated in greater detail for the sake of clarity or to enhance relevance, the participant responded, “I believe that it should be further researched how teaching concepts and making math a ‘sense-making’ activity affects students’ critical thinking and algebraic skills.”

The participant was asked what she felt was the point at which a mathematical education ceases to be practical for the public. She expressed what is thought to be a common opinion that, “I believe that if one is not pursuing a career that directly involves the need to know and understand complex concepts of math, then there is no need to teach it beyond the basic concepts.” With this statement in mind, the participant was asked to assume the role of a graduate-level mathematics student, and the question was posed at what time the participant would feel comfortable in teaching mathematics to others. The participant responded, “I am not certain that there is a point at which one could consider themselves having learned enough math to be comfortable educating others if you are pursuing graduate-level mathematics.”

Theoretical Perspective

When the participant was asked to assume the role of mathematics teacher or professor and asked what portion of a mathematics education was essential for the public, the participant responded quite simply, “Proportions, percentages, base ten

understanding, and basic algebraic concepts.” When the participant was asked, what was essential for a student to be successful in studying mathematics, the participant responded with a common theme, “I believe that it is essential for a student to be able to make math a ‘sense making’ activity as well as understanding basics such as number concept and base ten models.”

The participant expressed what is a common theme when asked what she felt was the biggest stumbling block for some students studying mathematics, the participant responded,

I believe that the biggest stumbling block for students having difficulties studying mathematics or relating to the study of mathematics, to be their past negative experiences with math as well as not fully understanding how what they are learning is meaningful to their future profession or everyday life.

Finally, when the participant was presented a scenario in which she was asked what part of mathematics instruction is critical for the improvement of mathematical comprehension, the participant responded, “Making math applicable as well as meaningful to the students that are learning it. Also, helping to make math a “sense-making” activity rather than just a memorization process.”

Opinions Regarding Mathematics (in general)

It was inquired what part of mathematical education is important or lacks importance in studying mathematics. The participant expressed, “It is important to have a basic foundation of math, and that I believe that this is important in a lot of ‘everyday’ life activities.” The participant also expressed that the study of advanced mathematical concepts is unnecessary if the techniques are not regularly used in their career. Finally,

the participant was asked to assume the study of mathematics served a purpose, and it was asked how she would describe this purpose. The participant expressed, “To be able to utilize and apply mathematical concepts in the everyday activities such as figuring out budgets, discounts, percentages, taxes, making change, etc.”

Participant # 02 – 10 – 2016 – NC

The second participant is a 29-year old full-time undergraduate student at Purdue University Northwest North Central Campus with a declared major in Elementary Education.

Emotional Association of Mathematics

The participant states that even though she had not taken any mathematics courses in the 10 years before her collegiate course, she traditionally did well in mathematics courses apart from geometry. The participant also stated she is worried about taking her current mathematics course because it had been so long since she last completed a course in mathematics. The participant stated that since she began her collegiate course in mathematics her opinion had changed regarding teaching children mathematics.

The participant’s interpretation of how others feel about mathematics involves a sense of regret, whereby some students do not enjoy mathematics, and when you say to them I’m heading to a math course their response is like, per the participant, “Oh, you’re going to math, I’m sorry.” Finally, when the participant was asked what her impression was as to the relevance of studying mathematics, she advised that even though an application may be not be used, the problem-solving skills associated with the application may prove beneficial with solving problems.

Opinions of Mathematical Education

When the participant was asked what portions of mathematics education needed to be researched in greater depth, the participant expressed that even though a great portion of mathematics involves formulas, greater emphasis should be placed upon problem solving not only for mathematics in general but for dealing with situations in life in general. When the participant was advised that one university has removed mathematics from its curriculum the participant stated she felt “sad.” She expressed the idea that since mathematics is such an integral part of our lives, it is something that is sorely needed. Finally, when asked at what point she would feel confident in educating others, the participant stated, “Learning is continuous and you can keep going with it.”

Theoretical Perspective

A similar motif is generated through each of the theoretical perspectives, particularly when the participant was asked to assume the role of a mathematics professor. The participant expressed in this role, “Problem solving is something that we all need to be familiar with.” Additionally, the participant also expressed what may be modern educators’ commonly held belief regarding repetitive school work in that for a student to be successful academically, “I feel that you just need to do it and keep practicing it; keep doing problems.” When asked what the participant felt was the greatest stumbling block for students studying mathematics, the participant stated, “That it’s not how many problems you do but getting the basics down and getting to know the process on how to do it.”

In the response to the scenario in which the participant is asked to assume the role of an educator, the question asked what the participant felt was critical for the improvement of mathematical comprehension. The participant expressed the following to the scenario.

I have had a variety of teachers when it comes to math as well as my children. I have a child in 3th grade and I see how he does math using different styles and methods that we are teaching to get the right information.

The response of the participant to the scenario shows the fact mathematical education is continuously evolving from the method of rote memorization which was the standard operating procedure for teaching throughout the clear majority of the 20th century. For a significant portion of time, the most common method for encouraging learning involves the use of rote memorization, particularly with learning vocabulary spelling and multiplication tables.

Opinions Regarding Mathematics (in general)

The participant was asked what she felt was the significance or lack of significance of studying mathematics. The participant expressed the significance of studying mathematics was that, “Math is important for the fact that it’s in so many different applications.” The participant was finally asked to assume mathematics served a purpose, and what this purpose was. The participant stated that the purpose in studying mathematics was, “Its purpose is to embrace new ideas and ways to do things.”

Participant # 03 - 10 - 2016 – NC

The third participant is a 47-year-old part-time undergraduate student at Purdue University Northwest North Central Campus with a declared major of Early Childhood Education.

Emotional Association of Mathematics

The participant was asked what her initial impression was of collegiate mathematics and the participant expressed apprehension; the participant advised she had bad experiences in grade school and high school as the result of teachers who did not foster the “student’s development of a deep understanding of the subject.” The participant has advised that her attitude has changed from “I can’t do this and I am horrible at this” to a positive attitude when informed that “math is not magic, but rather a sense-making activity.” When the participant was asked what, she felt, was the impression of others with regards to studying mathematics, she advised, “I find a balance of attitudes, from negative to positive, regarding the study of mathematics,” presumably like those of others studying mathematics collegiately.

The participant was asked what she felt was the relevance of studying mathematics and she advised, “The study of mathematics involves learning deeper problem-solving skills, which is vital in teaching children. As pre-service teachers, we must study all of the core subject areas to better teach our future students.” Finally, the participant was asked what her emotional attachment to studying mathematics was and advised,

My belief is that the emotional attachment that is generated from studying mathematics comes from our prior experiences, whether negative or positive. My prior stance (before college level) was a complete avoidance and feelings of negativity towards the subject. Now that I have had several positive experiences with the subject, I approach mathematics with more confidence.

Opinions of Mathematical Education

When the participant was asked what portion of mathematical education should be studied in greater detail to enhance relevance or for the sake of clarity, the participant advised, “Algebra with real world applications should be researched greater.

Understanding the process, not just memorizing the steps, should be a greater focus in the younger grades.” The participant was advised that one university has ceased to offer a curriculum in mathematics, and was asked at what point a mathematics education ceases to be practical. The participant advised,

Mathematics does not cease to be practical for the general public at any level. It is a core subject that intertwines with all subject areas. Like all subjects, different levels are practical for different levels of need, and the desired outcome. We use math every day. At what level is dependent on where you are in life; Student, high school math teacher, engineer, elementary school teacher, ironworker, at-home parent, attorney, etc.

Finally, the participant was asked to assume for a moment she was a graduate student studying mathematics, and asked at what point she felt she would be comfortable educating others. The participant stated, “That would likely be dependent on what level and area I wanted to educate others in.”

Theoretical Perspective

The participant was given the theoretical scenario in which she assumes the role of a mathematics teacher or professor, and asked what portion of mathematics education she felt was essential for the public. The participant advised,

To approach mathematics as a problem-solving activity with a hands-on and real world approach which would include a foundation of number sense, computation, algebraic thinking, geometry, measurement, data analysis, statistics, and probability.

The participant was asked, based upon your experiences studying mathematics, what do you feel is essential for a student to be successful in studying mathematics; the participant advised,

Based on my experiences, it is essential to approach mathematics as a problem-solving activity with a hands-on and real world approach. This should be taught by an educator with a deep belief in the fact that every student can understand mathematics if they are given the proper tools and knowledge to succeed.

The participant was asked what she felt is the greatest stumbling block for students who have difficulties studying mathematics or relating to the study of mathematics, and the participant advised, “Educators who do not make mathematics relatable to their students is the greatest stumbling block for students. Like all subjects, mathematics should be taught with thought given to real-world applications.”

Finally, the participant was presented with the scenario in which, based on her experiences with various mathematics teachers and professors, she was to assume the role of an educator, particularly with regarding to mathematics education, and asked what aspect of the instruction she would consider critical for the improvement of mathematical

comprehension. The participant advised with brevity, “hands-on experiences (the use of manipulatives).”

Opinions Regarding Mathematics (in general)

The participant was asked to describe the importance or lack of importance of studying mathematics, and the participant advised, “The studying of mathematics is equally as important as studying language arts, social studies, science, art, music, engineering, technology, and physical education.” The participant also advised, “They are all parts to a whole experience.” Finally, the participant was asked to assume that mathematics served a purpose, and what she felt the purpose in studying mathematics was. The participant advised, “The purpose of mathematics is to learn how to problem-solve and make sense of real-world problems.”

Participant # 04 – 16 – 2016 – NC

The fourth participant is a 28-year-old full-time undergraduate student completing her junior year at Purdue University Northwest North Central campus with a declared major in Early Childhood Education.

Emotional Association of Mathematics

The participant was asked what her initial impression with regards to collegiate mathematics were and advised, “I never had great experiences with Math but I have had some really great professors that made it easy.” The participant was asked if her initial impression has changed with regard to mathematics education, and the participant advised, “Because of some great professors I have had an increase in my confidence when it comes to my math ability.” The participant was asked what she felt was the

impression of mathematics education for other students, the participant responded candidly, “Usually a pain and waste of time.”

The participant was asked to describe the relevance of studying mathematics and the participant stated, “Having good math skills helps you have good problem solving skills as well as help you with every day activities like grocery shopping, budgeting, paying bills, leaving a tip, etc.” Finally, the participant was asked to explain her stance on the emotional reaction generated from studying mathematics. The participant advised, “I think that teachers need to work harder on their approach to teaching math and I think that this will help people feel less hatred towards math.”

Opinions of Mathematical Education

The participant was asked what part of mathematical education should be researched in greater detail for the sake of clarity or to enhance relevance; the participant answered concisely, geometry. In response to the question of at what point the participant felt mathematical education ceased to be practical for the public, the participant replied, “there is not much use beyond algebra.” Likewise, when the participant was asked to assume the role of a graduate student studying mathematics and when asked at what point the participant felt comfortable with educating others, the participant stated once she had mastered Trigonometry.

Theoretical Perspective

The participant was asked to assume the role of a mathematics teacher or professor and asked what aspect of mathematics she would feel is essential for the public. The participant replied, “Basic math as well as algebra and geometry.” The participant

was asked to reflect upon her experiences studying mathematics and asked what do you feel is essential for a student to be successful in studying mathematics. The participant replied simply, “Hands on practice not just paper work.” The participant was asked to identify what she felt was the greatest stumbling block for students studying mathematics, and the participant replied, “I think that many teachers believe there is only one way to teach a concept so if you can’t grasp the way that teacher is teaching the concept you will never understand it.”

Finally, the participant was presented with the scenario in which to date the participant’s experiences with mathematics teachers and professors and their various teaching styles are lived experiences unique to herself, and the participant was asked to reflect upon these experiences. The participant was then asked to assume the role of an educator, particularly with regard to mathematics education, given her experiences with studying mathematics, and asked what aspect of the instruction would she consider critical for the improvement of mathematical comprehension. The participant responded concisely, “One word: Differentiation.”

Opinions Regarding Mathematics (in general)

The participant was asked how she would describe the importance of or lack of importance of studying mathematics, to which the participant responded, “I think studying math is important, as I said earlier, it not only helps you function as an adult but it also improves problem solving skills.” Finally, the participant was asked to assume for a moment that mathematics served a purpose, and she was asked how she would describe this purpose. The participant responded, “To improve upon problem solving skills.”

Participant # 05 - 16 - 2016 – NC

The fifth participant is a 36-year-old part-time undergraduate student completing her sophomore year at Purdue University Northwest North Central campus with a declared major of Early Childhood Education.

Emotional Association of Mathematics

The participant was asked what her initial impression of mathematics was before college, and the participant replied, “I absolutely loathed math. I had a high school teacher that loved to make you feel stupid and I have hated math ever since I took her class.” The participant was asked if and how her impression of mathematics had changed since she had taken her first collegiate-level mathematics course. The participant replied:

I took two remedial math classes at the University of Memphis. Failed each class the first time around and then got an ‘A’ in each class the second time around. Sometimes it just takes me awhile to “get” it. I had the same teacher all four of those times and she started to crack my “math sucks-down with math” shell.

Fast forward about a decade and I’m at Purdue North Central. I took Math 111 online and passed it. I still thought math sucked though. Then I took a math class that Dr. Feikes taught. After having taken two of his classes I won’t say I’ve joined the math love parade, but I no longer go into a cold sweat when a math problem is presented to me.

The participant was asked what she felt was the impression of others studying mathematics, and the participant replied, “It’s really hard to speak for others since we are all individuals and all have our own opinions. I believe people either love math, hate math, or don’t care one way or the other.” The participant was asked to describe the relevance of studying mathematics. The participant responded:

We all do math every day even when we don’t realize it. When you cook and follow a recipe you are doing math. If you take medicine you need to know math

to count out the right pills. We need math to tell time. Math is used in hospitals. Math is used at banks. Math is used pretty much everywhere.

The participant was asked what stance she has on the emotional effects generated by studying mathematics, to which the participant responded:

I think that there needs to be more teachers who encourage their students and less who make their students feel stupid. No one is stupid. Just because a student hasn't grasped a concept yet doesn't mean that student won't grasp the concept down the road.

Finally, the participant was asked what portion of a mathematics education should be researched in greater detail for sake of clarity or to enhance relevance, to which the participant responded, "I really have no idea."

Opinions of Mathematical Education

The participant was asked at what point she feels mathematical education ceases to be practical for the public, to which the participant responded, "I don't think mathematics ever ceases to be practical. Most if not all of us use it every single day."

Additionally, the participant was asked to assume the role of a graduate student studying graduate-level mathematics, and at what point the participant would consider she has learned enough of mathematics to be comfortable educating others. The participant responded:

I'll be teaching grades three and younger. I'm comfortable now about my math skills in regards to teaching what children in those grades need to know. Now I am more interested in learning the methods for teaching math to children. As for teaching older students I would have to have many, many, MANY years of graduate level mathematics before I would even set a toe in say a high school classroom as a math teacher.

Theoretical Perspective

From a theoretical perspective, the participant was asked to assume the role of a mathematics teacher or professor, and then asked to describe what aspect of mathematics she would feel was essential for the public, to which the participant responded, “Addition, subtraction, multiplication, division, and basic algebra.” Based upon the experiences of the participant studying mathematics, the participant was asked what she felt was essential for a student to be successful in studying mathematics, to which the participant responded, “You need to understand what comes before something before you pursue what comes after something. Math skills build on each other and complement each other.

The participant was asked what she felt was the greatest stumbling block for students who have difficulties studying mathematics or relating to the study of mathematics, to which the participant responded, “I think the greatest stumbling block are the mental blocks we place upon ourselves. Thinking such as ‘I can’t do this’ or ‘I’ll never get this’ hinders us.”

The participant was presented with the scenario in which, given her experiences with mathematics teachers and professors and their various teaching styles, the participant asked to assume the role of an educator. The participant was asked what aspect of the instruction she would consider critical for the improvement of mathematical comprehension. The participant responded,

Teach students the word “Yet”. Whenever they say they can’t do something that is hard for them say “yet”. I can’t add... yet”. I don’t get calculus...yet”. Also, if

a student is struggling offer as much help as possible. Don't make your student feel like a dunce.

Opinions Regarding Mathematics (in general)

In this final section the participant was asked to describe the importance or lack of importance of studying mathematics, to which the participant responded, "Math is very important. Even though I would love to say it isn't I know that isn't true. Math is everywhere. It is far from my favorite subject, but I do know it is important." Finally, the participant was asked to assume for a moment that studying mathematics served a purpose. The participant was asked to describe the purpose, to which the participant responded, "Math helps us to advance society. If it wasn't for math we might never have flown to the moon, landed a rover on Mars, or any of the other amazing things that require math."

Participant # 06 – 16 – 2016 – NC

The sixth participant is a 37-year-old full-time undergraduate student completing her junior year at Purdue University North Central campus with a declared major in Early Childhood Education.

Emotional Association of Mathematics

The participant was asked what was her initial impression of mathematics was before studying mathematics collegiately to which the participant replied, "Math is not an easy subject for me, making me uneasy." Additionally, as a follow-up question the participant was asked if her impression of mathematics had changed after taking mathematics courses collegiately, to which the participant responded, "Since I began

taking MA 137-139, geared toward teaching. It is explained differently and I am more comfortable.” The participant was asked to assess what other students might feel regarding studying mathematics, to which she replied, “Many people are nervous about Math and do not feel confident in their ability.”

The participant was asked what the relevance of studying mathematics was, given the fact that many younger students may argue the point in studying mathematics if very little of the subject is used in life, to which the participant replied, “We use Math every day. You have to know many more parts than you will use because it builds upon itself.” Finally, the participant was asked to describe her emotional association with studying mathematics, to which the participant responded, “It is great when you have a moment where you know you ‘get it.’”

Opinions of Mathematical Education

The participant was asked what she felt was necessary to be researched in greater detail for the sake of clarity or to enhance the relevance of studying mathematics, to which the participant responded concisely, “Short cuts are great.” Additionally, the participant was asked at what point she felt mathematical education ceases to be practical for the public, to which the participant responded, “I don’t understand not having Math as a part of any curriculum.” Finally, the participant was asked to assume the role of a graduate student studying mathematics and asked, at what point she would consider she have learned enough of mathematics to be comfortable educating others. To this the participant responded, “Everyone has their own point of understanding something

thoroughly. I just want to be confident enough that I understand the material I am teaching.”

Theoretical Perspective

The participant was asked to assume the role of a mathematics teacher or professor from a theoretical perspective and asked what aspect of mathematics she felt was essential for the public, to which the participant responded, “I feel that the public most commonly uses percent(age)’s, fractions, and measurement.” Second, the participant was asked, based upon her experiences in studying mathematics, what she felt was essential for students to be successful in studying mathematics, to which the participant responded, “A teacher who can explain examples that make sense.”

The participant was asked to describe what she felt was the greatest stumbling block for students who have difficulties studying mathematics or relating to the study of mathematics, to which the participant responded, “Simply, not getting it (mathematics) before the teacher moves on.” Finally, the participant was given the scenario in which she was asked to examine her lived experiences with her mathematics teachers and professors and their individual teaching styles. The participant was then asked what aspect of mathematics instruction she felt was critical for the improvement of mathematical comprehension, to which the participant responded, “Time in each section, building up with everyone gaining understanding and confidence.”

Opinions Regarding Mathematics (in general)

The participant was asked her general opinions with regard to studying mathematics, and asked how she would describe the importance of or lack of importance

of studying mathematics, to which the participant responded, “I feel that our nation needs to catch up to some areas of our world in our Math skills. It is one of the foundational subjects in education.” Finally, the participant asked to assume that studying mathematics served a purpose, and the participant was asked to describe this purpose, to which the participant responded, “It helps with problem solving, every day measurement, and building our world.”

Important Points Requiring Clarification

The importance of clarifying information provided because of the responses to the questionnaire is contingent upon the interpretation, analysis, and inferences generated because of the research as outlined by Facione and Gittens (2013a).

Interpretation

Several key points of clarification are required for the data provided by the participants to be meaningful. For instance, how we should interpret what the participants have stated in response to the questionnaire is of interest. The open-ended nature of the questionnaire seeks to promote a clear expression of the experiences of the participants without any pretense in their responses. By ensuring the validity of the responses, the objective truth of the same becomes evident. Only when the responses are evaluated does the objective truth of the statements typically become subjective in nature. Phenomenology’s most important accomplishment, according to Merleau-Ponty (2014), involves what Merleau-Ponty expresses as extreme subjectivism combined with an extreme objectivism. Finally, the question is raised regarding how best to categorize the

responses through the context of the analysis techniques selected, which in turn do not unnecessarily influence the categorization of responses based upon researcher bias.

Analysis

Everyone has a different grasp of vocabulary, communication skills, and ability to relate his or her experiences to an event. For the participants to express themselves in a constructive manner, in response to structured questions, often involves a certain degree of grammatical and literary collaboration. For instance, if participants attempt to express their experiences using analogies, it is important to understand the context in which their experiences were generated, as well as the possible generalizations derived from said analogies. An analogy, per Merleau-Ponty (2014), is far easier for an individual to examine when the analogy is examined based upon the context in which it is generated. Mankind, in general, “seeks [...] a common material property from which he could deduce the identity of the two relations as if from a middle term” (p. 129). Here the middle term is a common point of reference between the two extremes of the analogy.

Inferences

Several key concerns need to be addressed for any inferences to be meaningful. For instance, it must be addressed up front what data is provided directly relates to an event under investigation (Facione and Gittens, 2013b). For example, as the information being generated relates to the experiences generated through the study of mathematics, events related to events which do not directly influence the participant are inconsequential to the experiences and study. Additionally, it is also of interest how the expressions of the experiences provide meaningful data as a form of evidence which may

or may not provide data related to the study (Facione and Gittens, 2013b). Finally, before we accept or deny any assumptions because of the feedback provided, it is important to know what additional information is necessary for the meaning of the experiences to be clear.

Identified Themes

Several common themes were readily identifiable as a result of the research, in particular when compared with the data collected by the preliminary interviews. For instance, in 83.3% of the women interviewed (5/6), the women had bad experiences in studying mathematics, either in grade school or high school. As a result, their general attitudes were negative when it came to studying mathematics. With the exception of Participant # 02-10-2016-NC, who expressed that she had good experiences in studying mathematics before her collegiate studies, the remainder expressed an improvement in the elimination of any mental “block” which may have influenced their reluctance to study mathematics.

An additional theme identified as a result of the research involves the amount of anxiety that was present before studying mathematics collegiately. Again, 83.3% of the women interviewed (5/6) expressed either anxiety or a sense of helplessness with regard to studying mathematics. The sense of dread when it came to studying mathematics before college in five of the six cases created a self-imposed reluctance and mental “block” which prohibited the women from actively declaring majors in which mathematics assumed an active role in the studies.

As expressed by each of the women in the study, their attitudes had improved regarding the studying of mathematics. While Participant # 06-10-2016-NC expressed she did not care for studying mathematics, she expressed that her ability to process the information was greatly improved from when she had last studied mathematics. Additionally, two of the six women expressed that their attitudes with regard to studying and teaching mathematics would have improved further if the study of mathematics had involved a greater emphasis on studying problem-solving skills with which other students could readily apply mathematics to solving issues in real life.

Synthesis

A synthesis of the results illustrates that a clear majority of the women in the study have had some degree of anxiety with regard to studying mathematics, with varying levels of disparity in studying mathematics, particularly in response to bad experiences they had in secondary education. Additionally, the longer the gap between studying mathematics in secondary education and collegiately does not reduce the reluctance in studying mathematics. In fact, in the majority of the cases the level of anxiety in studying mathematics grew; it was generated during their secondary education, with some reduction in mathematics anxiety during the collegiate studies. Finally, even though the attitudes of the women in the study improved regarding the study of mathematics, five out of six participants stated that they believed the attitudes of other college students with regard to the study of mathematics are negative.

Conclusion

The observations of the women who participated in the research are reflective of current educational methodologies taught and employed in secondary education in the United States. The methodology taught to the women in the research, as a result of their collegiate studies, had clearly changed before taking college courses in secondary education at Purdue University. The methodology now taught incorporates the principles of metacognition; the concept that before an individual may properly address a subject of study, he or she must first be cognitively aware of his or her limitations. As the participants in the study each emphasized varying subjects they felt were necessary in order for educational reform to be relevant, it may be argued that the women essentially declared what subjects they themselves felt were important to understanding mathematics.

CHAPTER 5. DISCUSSION, IMPLICATIONS, RECOMMENDATIONS

Discussion

The purpose of this phenomenological qualitative dissertation is an examination of the essences of female, undergraduate non-traditional students studying mathematics at either the Purdue University Northwest, North Central or Calumet campuses, collectively known as Purdue University Northwest. The phenomenological examination of the lived experiences of the women in the study provide the data by which conclusions may be drawn in summary with regard to the reluctance of women studying mathematics collegiately. However, a gap exists in research regarding how phenomenology is addressable in the context of constructivism.

Current literature exists which supports the conclusion that women are more reluctant to study mathematics, particularly in response to bad experiences in secondary education, due to the existence of mathematical anxiety (Robinson and Suinn, 1972; Tobias, 1978; Hartman-Abramson, 1990; Raver, 2014). Mathematical anxiety was predominant before studying mathematics collegiately for five of the six women interviewed. For instance, in 83.3% of the women interviewed (5/6), the women had expressed bad experiences in studying mathematics, either in grade school or high school, participant # 02-10-2016-NC being the only exception, having expressed she had good experiences in studying mathematics in her secondary education.

83.3% of the women interviewed (5/6) expressed either anxiety or a sense of helplessness with regard to studying mathematics. The sense of dread when it came to

studying mathematics before college in five of the six cases created a self-imposed reluctance and mental “block” which prohibited the women from actively declaring majors in which mathematics assumed an active role in the studies. While Participant # 06-10-2016-NC expressed that she did not care for studying mathematics, she expressed her ability to process the information was greatly improved from when she had last studied mathematics.

Results of Analysis

A synthesis of the analysis illustrates a clear majority of women have some degree of anxiety with regards to studying mathematics, particularly in response to bad experiences they had in secondary education. Additionally, the longer the gap between studying mathematics in secondary education and college does not reduce reluctance in studying mathematics. Based upon the interviews during the research, there is not a direct correlation between the level of anxiety in studying mathematics in secondary education and collegiately, thus resulting in a reduction in the reluctance in studying mathematics. In fact, in the majority of the cases the level of anxiety in studying mathematics grew. Finally, even though the majority of the attitudes of the women in the study improved regarding the study of mathematics, five out of six participants stated they believed that the attitudes of other college students were negative with regard to the study of mathematics.

A series of recurring themes was identifiable through the analysis of the responses to the questionnaires, to which several have common associations with sympathetic responses to stimuli which have resulted in the equivalent of a “fight or flight” response

(Davis & Palladino, 2004, p. 44). While many of the participants expressed difficulty in studying mathematics before college, in none of the cases were they consistent with the learning mathematical disorder as outlined by Durand and Barlow (2006). A learning mathematical disorder, as outlined by Durand & Barlow (2006), involves mathematics performance that is significantly below age norms.

Emotional Association of Mathematics

Intimidation

The participants' initial impressions of mathematics exhibited an emotional range of feelings from intimidation, as with the announced response of participant # 01-10-2016-NC, to worry for participant # 02-10-2016-NC, through what could be considered a sense of implied helplessness as identifiable through emotional coding by Participant # 03-10-2016-NC. Participant # 06-10-2016-NC went so far as to state, "Math is not an easy subject for me, making me uneasy." In each case, the anxiety driven by the mere thought of studying mathematics before college was so profound that it had manifested as a "general feeling of apprehension characterized by behavioral, cognitive, or physiological symptoms" (cited by Davis & Palladino, 2004, p. 512; Zaslavsky, 1994; Silliman-Karp, 1988; Hart, 1989).

However, the participants also expressed a positive change in their opinions on the study of mathematics due to the fact that mathematics, as expressed by Participant #3, is "not magic, but rather a sense-making activity." These statements suggest the logical nature of the subject may be supported by an approach which combines both a psychological and deductive nature to the study of the subject. Furthermore, the

approach that is expressed by Participant #3 is supportive of the constructivist ideology of how the application of logic is related directly to the phenomenological study of mathematics.

As previously mentioned under Von Glaserfeld's (date) Radical Constructivism, the logical formation of knowledge in conjunction with the experiences of individuals is contained within those expectations the students held upon themselves, and their development in the study of mathematics assumes the logical basis of the knowledge.

Implications

A clear implication of varying levels of anxiety associated with studying mathematics provides an environment in which, even though the students have a sense of distress from studying mathematics, they seek understanding in studying mathematics when they view their capabilities associated with studying mathematics as limited.

Limitations

A simple limitation which results from the various levels of mathematics anxiety involves the tendency of students to avoid programs which incorporate a mathematical requirement for study. For instance, a student may be wary of studying engineering or nursing, knowing either program would incorporate a heavy dependency on mathematics. As a consequence of this segregation of programs based upon the study of mathematics, students are less likely to invest time in programs which result in more in-demand job opportunities. Additionally, as STEM programs are in high demand, students are less likely to enter these fields, thereby contributing to the shortage of STEM program graduates.

Experiences in Secondary Education

In 83.3% of the cases (5/6), the participants had bad experiences in studying mathematics during their secondary education, either in grade school or high school. The clear exception was Participant # 02-10-2016-NC who expressed that she had positive experiences in studying mathematics in high school which carried over to college. The findings are supportive of the concept of either negative reinforcement as illustrated by Participants #s1, 3, 4, 5, and 6, or with positive reinforcement illustrated by Participant #2, establishing a conditioned response. However, Participant # 02-10-2016-NC has expressed some nervousness in taking her current mathematics course, as she has not taken a mathematics course for 10 years before her current class.

Implications

A clear implication of varying levels of influence the students received before college with respect to studying mathematics presents an argument whereby it might be advantageous to examine the opinions of educators in secondary education to determine if commonalities exist in their approaches to the teaching of mathematics, or to determine if the experiences they developed when studying mathematics influence their particular teaching styles.

Limitations

A simple limitation exists whereby a variety of instructors in mathematics may have a profound impact on their students, and their general attitudes toward the study of mathematics. As was suggested in the student's responses, opinions and attitudes toward the study of mathematics are viewed with varying degrees of reservation regarding the

relative necessity and relevance to a particular degree path. Additionally, as also alluded to by the students' responses, the relevance of mathematics continues even outside one's career; the necessity of mathematics one may use on a regular basis with activities of daily living requires the strong development and reinforcement of basic mathematics.

Confidence

All the participants expressed an increase in confidence and/or comfort in studying mathematics after having good experiences in studying mathematics collegiately, even past the point where a mental "block" no longer exists for Participant # 01-10-2016-NC (personal communication, 2016). The mental "block," declared by Participant # 01-10-2016 acts as a form of psychological defense mechanism for a period when the participant either consciously or unconsciously views the study of mathematics as a form of psychological threat. The mental "block," per Participant # 01-10-2016 also was described by Bradford (personal communication, 2016) as well as by Davison (personal communication, 2013).

When the participants were asked, what others might feel when it comes to studying mathematics, the consensus was negative, with responses ranging from either general intimidation as expressed by Participant # 01-10-2016-NC, to regret as expressed by Participant # 02-10-2016-NC, to "people either love math, hate math, or don't care one way or the other" as expressed by Participant # 05-10-2016 (personal communication, 2016). The anxiety in these cases may be interpreted as an irrational fear of the subject due to the stress the subject generates while it is being studied. The anxiety

generated is not for the subject at hand, in this case mathematics, but for the fear generated because of the actual stressor.

In response to the question regarding the relevance of studying mathematics, Participants # 01-10-2016-NC and # 06-10-2016-NC expressed that math is used every day, summarized by the response, “without an understanding of Mathematics, it would be difficult to do things like calculating taxes when shopping, calculating discounts, measuring, budgeting, et cetera,” as expressed by Participant # 01-10-2016-NC. Of interest is how Participant # 02-10-2016-NC expressed a concern over the process for solving problems instead of concentrating on the solution with the comment, “It’s not that you are going to use this application, but you’ll use the problem solving to find the solution” (personal communication, 2016).

Implications

Silliman-Karp (1988) explained how the attitudes of secondary education teachers may influence the results of their students when it comes to studying mathematics. What is implied by Silliman-Karp (1988) is that if the attitude of the teacher is positive with regard to studying mathematics, this will be reflected in the manner in which he or she teaches the subject. Likewise, if the teacher has a negative attitude, either with regard to the subject being taught or toward teaching in general, this attitude will reflect in the outcomes of his or her students Silliman-Karp (1988). As a result, it is ideally beneficial to students if their teachers have a positive attitude to the study of their subject, particularly mathematics.

Limitations

Due to the personalized attitudes of the participants with regard to their responses to the questionnaire, the feedback is not objective. However, the subjective nature of the responses clarifies the responses to be truly reflective of the participants, consistent with their educational background and ability to express themselves in a constructive manner. Additionally, as all of the participants are potentially illustrative of secondary education students, their attitudes are potentially illustrative of other secondary education students and new educators.

Reflective criticism of the educational system in the United States serves the populous as showing potential educators of northwestern Indiana. While the limitation exists, these attitudes may not be reflective of other education students from other parts of the United States, particularly those of a larger university campus, the reflections illustrate common educational shortcoming and attitudes that exist locally.

Opinions of Mathematics Education

The participants were asked what they felt should be researched in greater detail for sake of clarity or to enhance relevance involving mathematics. The responses showed that the participant had either a lack of personal insight and apathy towards the subject or a concern of increasing the amount of “sense-making,” as described by Participant # 01-10-2016-NC. Participant # 03-10-2016-NC was very specific with her response, having stated, “Algebra with real world applications should be researched greater. Understanding the process, not just memorizing the steps, should be a greater focus in the younger

grades” (personal communications, 2016), with Participant # 04-10-2016-NC being more precise stating simply, “Geometry” (personal communication, 2016).

In response to the question at what point does mathematics education cease to be practical, Participant # 01-10-2016-NC expressed that in general, if a career or field does not necessitate the use of advanced mathematics, it should not be necessary to study mathematics beyond that point. In contrast, Participant # 02-10-2016-NC’s response expressed that she found it sad that a university or college would drop mathematics from its curriculum, as mathematics is something that is needed in our everyday lives. For example, per Participant #02-10-2016-NC, “I am not certain the reasoning behind teaching trigonometry, for example, if this is not going to be utilized directly in one’s field” (personal communication, 2016). On a similar note, Participant # 05-10-2016-NC’s statement that mathematics never ceases to be practical based upon the fact that “most if not all of us use it every single day” (personal communication, 2016).

The question was posed in which the participants assumed they were studying graduate level mathematics. It was then asked at what point, given this scenario, when they felt they would be comfortable teaching others mathematics. The responses, while open-ended, exhibited similar themes. For instance, Participant # 01-10-2016-NC expressed the fact that she is not certain there is a point at which someone could possibly consider themselves competent enough in mathematics to teach others comfortably. Participant # 05-10-2016-NC expressed that even though she teaches mathematics to third graders and below, and is comfortable doing so, she felt it would be necessary to take several years of graduate-level mathematics before she would feel comfortable

teaching mathematics in high school. This fact is also reiterated in a similar fashion that learning is a continual process which in theory never ends.

Implications

As implied by the data provided by the participants, when a student has a positive self-image regarding the study of mathematics, generally the student finds she tends to do better in studying mathematics. This translates towards attitudes the students have with regard to studying advanced mathematics, particularly in preparation for teaching mathematics to other students in a form of mathematical self-concept. As explained by Gourgey (1982), a mathematical self-concept “refers to beliefs, feelings or attitudes regarding one’s ability to understand or perform in situations involving mathematics” (p. 5). The bearing of comprehending the principle of mathematics self-concept, in the context presented by Gourgey (1982) is that the student’s self-perceived ability involving the study of mathematics has a direct effect upon his or her relative success or failure.

Limitations

Supportive of the concept of positive reinforcement, the women interviewed expressed conditional signs of positive reinforcement through their educational programs, particularly in reference to the study of mathematics. While mathematics may be viewed as abstract with regard to the study of higher-level mathematics courses, a limitation exists in which the students are illustrative of students who have studied lower levels of mathematics necessary only for the completion of their programs. Potentially, had the students studied higher levels of mathematics, their opinions might have been more

reflective of mathematics students in general, but not necessarily reflective of secondary education students.

Theoretical Perspective

As education students, each participant was asked to assume the role of a mathematics teacher or professor, and then asked, what aspect of mathematics she would feel is essential for the public. Responses ranged from basic mathematics and algebra (Participant # 05-10-2016-NC), proportions, percentages, base ten understanding, basic algebraic concepts, (Participant # 01-10-2016-NC), basic math including algebra and geometry (Participant # 04-10-2016-NC) to problem solving (Participant # 02-10-2016-NC). Perhaps the most significant response which stressed currently emphasized pedagogical theories was generated by Participant # 03-10-2016-NC, who stressed problem-solving activities with hands-on and real-world applications.

On a similar note, asking the participants what they felt was essential for students to be successful in studying mathematics illustrated what the participants felt were the expectations of students. For instance, Participant # 01-10-2016-NC expressed that it is necessary to make math a “sense-making” activity, a theme identified previously. Additionally, Participant # 03-10-2016-NC stressed the concept of scaffolding with the response, “Math skills build on each other and complement each other” (personal communication, 2016), a sentiment like the response from Participant # 05-10-2016-NC which states, “Math skills build on each other and complement each other” (personal communication, 2016). In contrast, the response of Participant # 04-10-2016-NC which stressed hands-on practice and not paperwork, commonly called busywork, is paralleled

with the response by Participant # 02-10-2016-NC, which stressed that one should just keep practicing and doing the related problems.

In response to the question of what the participants felt was the greatest stumbling block for students who have difficulties studying or relating to the study of mathematics, the responses aligned in two specific frames of mind of the educator and student. First, as previously identified by the question of initial impressions of mathematics, the response by Participant # 01-10-2016-NC reinforced the cause by relating the difficulties in studying mathematics to negative experiences with math, in addition to not understanding how the study of the subject is meaningful to their future professions. This frame of mind also imprints on students the mentality, as announced by Participant # 05-10-2016-NC, that “‘I can’t do this’ or ‘I’ll never get this’” (personal communication, 2016).

On the other hand, the direction taken by the responses to the question as to the stumbling block for students studying or relating to mathematics involves the question of either the issue of getting the basics down with the hope of relating to the material, as described by Participant # 02-10-2016-NC, or the issue that teachers only know one way to teach a concept. This latter issue often results in the attitude that if the student does not grasp the material via the method which the teacher is using, he or she would never understand it – in essentially a one-size-fits-all mentality. Additionally, Participant # 03-10-2016-NC expresses that “‘Educators who do not make mathematics relatable to their students is the greatest stumbling block for students’” (personal communication, 2016).

As one might expect, the question as to what aspect of mathematics instruction was felt paramount to improving mathematical comprehension drew parallels with the question of what was the greatest stumbling block for students studying mathematics. For instance, when Participant # 01-10-2016-NC expressed that it was by “making math applicable as well as meaningful to the students that are learning it” (personal communication, 2016), it also increases the effect of sense-making, and not just a process of memorization.

Participant # 02-10-2016-NC explained a modern trend in education involving her son in third grade, where he is taught math through different styles and methods from those she was taught. Techniques such as these, and those who emphasize teaching the student the word “Yet” (Participant # 05-10-2016-NC, personal communication, 2016) reinforce that the student may have some difficulties in studying mathematics, but the solution to the problem may involve taking a different frame of mind in order to be successful.

Implications

Student expectations with regard to the study of mathematics have a profound effect on how mathematics is presented. Based on the explanation of mathematical self-concept, students who view their capabilities as limited with regard to studying mathematics are less likely to succeed in studying mathematics, often with attitudes similar to Participant # 05-10-2016-NC, who expressed, “I’ll never get this” (personal communication, 2016). Likewise, it may be considered that if a teacher can impress upon the student a positive attitude with regard to studying mathematics by creating methods

by which the students can associate with the material through a case of “sense making,” as expressed by Participant # 01-10-2016-NC, potentially the students may perform better.

Limitations

The feedback provided by the women interviewed are potentially illustrative of the current state of affairs with regard to the production of secondary education teachers, emphasizing particular aspects of mathematics education. Additionally, as the sample size of those interviewed was limited, with six non-traditional female students studying secondary education, any inferences are subjective of being truly reflective of secondary education in general.

Opinions Regarding Mathematics (in general)

The responses of the participants on the question of the importance or lack of importance is clearly illustrative of the necessity of studying mathematics in secondary education. For instance, Participant # 01-10-2016-NC expressed that it is important for students to have a firm foundation in basic mathematics. As basic mathematics is construed as the foundation for more advanced topics in mathematics, constructivist principles dictate the necessity of studying mathematics for it to act as the cornerstone of further academics involving mathematics. Additionally, as expressed by Participant # 01-10-2016-NC, as mathematics is used in everyday life, it may not be necessary to study advanced mathematics if the complex mathematics concepts are not readily used in one’s career. For instance, if one were to begin an entry-level nursing program, it is not

necessary for the individual to study elementary calculus; or to study multivariate calculus if one's sole intention is to teach elementary school children.

Participant # 03-10-2016-NC expressed that mathematics is just as important as the study of physical education, science, art, music, as well as language arts as necessitated from a holistic approach to education. This holistic approach establishes the examination of the student entity and not just a person studying a topic as anticipated for one's career. In this sense, secondary education may be interpreted as an early establishment of a liberal arts education with several key components establishing the basis for a well-rounded student.

Participant # 04-10-2016-NC expressed the fact that mathematics is crucial for the development of good problem-solving skills. As the skill of problem-solving is essentially universal, particularly in response to the necessities of secondary education, the development of problem-solving skills is necessary for a student to be able to solve problems by thinking metaphorically "outside the box," much in character with a free thinker by way of a liberal arts education.

The implications of the court decision *Brown v. Board of Education of Topeka* (347 U.S. 483 (1954)) and reports which established the fact that the United States is falling behind other industrialized nations, such as those used in support of No Child Left Behind and Race to the Top, are emphasized in context by Participant # 06-10-2016-NC's response which stated, "I feel that our nation needs to catch up to some areas of our world in our Math skills. It is one of the foundational subjects in education" (personal communication, 2016). As a foundation for modern education, the necessity of studying

mathematics cannot be over-emphasized due to the fact the skills used in mathematics for problem solving have paramount ramifications for other subjects as well.

A scenario was presented in which the participants were asked to assume for a moment they were studying mathematics and that the study of mathematics served some distinct purpose. When the participants were asked how would they describe this purpose, Participant # 05-10-2016-NC expressed mathematics is critical in the advancement of a society technologically. To Participant # 04-10-2016-NC and Participant # 05-10-2016-NC, the purpose of studying mathematics is to improve problem-solving skills, as well as to make sense of real-world problems. On a similar note, Participant # 03-10-2016-NC expressed that, while the study of mathematics does serve a purpose, that purpose involves embracing new ideas and ways of solving problems, in line with the communications previously identified.

Implications

The implications of calling for more coverage in mathematics education with emphasis on problem-solving skills are that it could potentially serve students in the United States by providing the grounds for further advances and practice in addressing problems potentially solvable by mathematics. Additionally, as the goal of instruction is not the mere memorization of facts, as criticized by Dewey in the early part of the 20th century, but learning new ways to think in order for the individual to apply what bodies of knowledge he or she possesses and further acquires.

Limitations

The opinions in general of the participants with regard to the practicality of studying mathematics are illustrative of a small sample size with a wider variety of responses possible if the sample size were taken from a wider population not entirely restricted to education students at a Midwest university. Potentially of interest is how secondary education educators' opinions are truly reflective of educators in general regarding the necessity and restrictive nature of mathematics education. As teaching practical problem-solving is called for by several of the women in the study, the responses calling for more coverage of problem-solving skills is potentially limiting in nature. The question would be raised at what point would the next topic be of practical importance to emphasize in mathematical education, and then next to the point whereby a slippery slope argument could be constructed. Potentially the argument would require an extended amount of time to address all of the topics which would be severely limited by budget and educational policies.

Recommendations for Practice

A practical recommendation of practice with regard to mathematics education would be incorporating problem-solving skills in education, particularly with the studies of algebra and geometry. As algebra, may be construed as a keystone mathematical topic of high-level mathematics studies, any attempt to encourage the study of algebra and potentially geometry would prove to be beneficial to students in general. Additionally, by paying note to the response and opinions of educators who instruct in mathematics, the educational system may find the feedback to be more objectively reflective of issues

addressed by educators on a regular basis. Finally, as Dewey was critical of the trend of rote memorization of mathematical facts, he emphasized “the continuity between processes of individual learning and the goals of specialized inquiry” (Phillips, 1999, p. 1).

Curriculum and Instructional Design

Changes to instructional design, and curricula in particular, must be reflective of the educational environment and policy as they are deemed fit to maintain and improve education. As the role of rote memorization was critiqued earlier in the 20th century by Dewey in conjunction with his pragmatism, and eventually by modern educational theorists, by improving the portability of mathematics instruction the educational establishment could potentially improve not only the state of educational practices as held by the United States Department of Education and respective states, but potentially the overall outcomes of the same. However, these practices have potentially contributed to a decline between 2009 and 2012 in which the United States had fallen several places behind those of other westernized nations with regard to mathematical education. According to the Organisation for Economic Co-operation and Development (OECD), the United States has fallen from the 25th position to 31st according to the results of the Programme for International Student Assessment (PISA) conducted triennially by the (word?) (2013).

Critics hold that educators should also be teaching students life skills and not just those subjects evaluated on standardized tests (Nelson, personal communication, 2016). This paradigm emphasizes a “collection of logically related assumptions, concepts, or

propositions that orient thinking and research” (Bogdan and Biklen, 2007, 274). The logical basis of instruction must be oriented to providing instruction not only current with educational traditions such as reading, grammar, and mathematics, but also with the instructional needs for students to excel in the 21st century.

Implications for Research

In order for educators to better prepare instruction with the intention of reaching all students, regardless of gender, it is necessary first to re-examine the approaches by which the instruction is generated. For example, the re-examination of the foundations of pragmatic instruction may address the shortcomings as previously mentioned with the intention of improving said instruction. Additionally, as instruction and instructional design are improved, new bodies of research open up with the intention of producing instruction which is capable of reaching all students, regardless of context and gender.

Modification to Instructional Design

Several potential forms of instructional design are possible with a careful review of pre-existing and accepted ideologies. Potentially, it is possible to re-address instructional design with the lessons learned through the practical application of logical empiricism, which in theory could involve a heavy dependence upon practical application of instruction when solidly founded through logically sound rational applications of pedagogy.

Pragmatic Relevance in Instructional Design

The criticisms of the pragmatic relevance of constructivism involve the dependence upon rote memorization as illustrated by the criticisms of Dewey in the early

part of the 20th century. This criticism is highly relevant today to the study of mathematics and the repeated reliance on heavy memorization of mathematical formulas and techniques for solving mathematical problems without incorporating the use of technology, and without a clear goal in mind. It is potentially advantageous for educators who incorporate the use of technology to the pedagogy associated with study of mathematics to embrace the pedagogy of teaching critical thinking skills as it signifies a clear change in the mentality necessary for improving instructional design.

STEM Considerations

As there is a heavy demand for graduates of STEM (Science, Technology, Engineering, and Mathematics) programs, changing the goal of instruction to the development of critical thinking only reinforces the skills necessary to be competitive in STEM programs. As graduates of STEM programs are in high demand, ensuring that instructional design caters to addressing genders, particularly in the instruction of mathematics, may provide the means by which education in the 21st century provides sufficient numbers of graduates capable of meeting the demands of STEM programs.

Recommendations

Due to the nature of the study on-hand and the various approaches available to the study of phenomenology, be they transcendental, sociological, or purely on linguistic terms of investigating how the essences of experience are expressed, it would be of interest how the study of mathematics may be viewed phenomenologically in any combination of these contexts. As the study on-hand also approaches the study of

phenomenology and mathematics through the context of constructivism, it would also be interesting to note how other scientific subjects are viewed in much the same fashion.

Improvement on Research

It is possible for the research to be improved by addressing a larger body of students in either an Education program or possibly through a Mathematics and Physics program. Additionally, as the research sought to seek understanding of the phenomenological interpretations of female students involved in an Education program, it is potentially possible to incorporate multiple groups of students in other Education programs through multiple colleges and universities in order to obtain information from a more diverse student body.

Comparison of Phenomenological Perspectives

A gap was identified in how the examination of how Husserl's approach to the study of phenomenology compares with that of his teacher Brentano and his student Heidegger in the context of what would later be considered constructivist. Clearly the academic politics of the times involved a clear differentiation between how Brentano and Husserl interacted, and how Heidegger used his political influence to grossly restrict and deny Husserl academic access to first teaching and then to academia entirely, regardless of any involved clearly biased ideology and propaganda. The same study may be approached from the examination of characteristic teaching traits and methodologies from a purely psychological perspective.

Comparison of James and Bergson

According to Hakim (1995), both James and Bergson were dedicated to the study of life, in a metaphorical sense, and their views were in the context of empiricism, whereby the mind “goes by facts” (p. 540). A gap in the research illustrates how a phenomenological presence of experiences, particularly with respect to the research participants enters the consciousness, as the “touchstone of truth is experience” (Hakim, 1995, p. 540), and the justification of experiences beyond that verified empirically through the consciousness “can never compel us to admit its existence” (p. 540). Thus, an additional topic of interest for study is how the study of mathematics influences these experiences on purely ideological academic grounds.

Constructivist Considerations in Phenomenology

Another topic of interest for further investigation identified by a gap in the research is how the study of the phenomenological considerations of mathematics is viewed in the context of both the continental philosophies of the 20th century as well as the precepts of the latter part of the 19th century. As phenomenology may be viewed by interpretive phenomenological analysis as an examination of the lived experiences of the participants and how the participants generate meaning from the experiences, how the participants view the study of mathematics based upon their interpretations of their lived experiences on both transcendental and hermeneutic grounds is of interest.

Phenomenological Examination of Critical Thinking Skills

A final prospective target of investigation exists in which the considerations of the constructivist principles under investigation through phenomenology would be fruitful –

to examine how the lived experiences of mathematics students influence the results on Cornell Critical Thinking Test (CCTT), the Watson-Glaser Critical Thinking Appraisal (WGCTA), or the California Critical Thinking Skills Test (CCTST). In any of those cases the assessments would show a distinct parallel between the skills necessary to be successful in studying mathematics with the development and use of critical thinking. Additionally, as there is a limited amount of research into the parallels between the study of mathematics and the development of critical thinking, any conclusions which may be drawn would prove to be beneficial to curriculum design which fosters critical thinking.

Conclusion

The qualitative basis of the research presented illustrates that while the current pedagogy involved in mathematical instruction has improved from those established in the latter part of the 19th century, and those of the early 20th century, particularly in response to the criticism of educational theorists, it is rooted in those views of Dewey's pragmatism and Carnap's logical empiricism. The constructivist principles are implied from the literature involving Von Glasersfeld (1989) and Yager's (1995) approaches to constructivism by paralleling the three principles important to the promotion of learning as outlined by Erskine (2010). Current instructional design and pedagogy, according to these three principles, involve the promotion of engaging students' preconceptions in regard to the world, promoting the development of deeper understanding of content knowledge, and promoting the development of metacognitive skills. The interviews conducted with the female non-traditional students illustrate the necessity of

metacognition in instruction design by knowing one's limitations in a subject; in this case, the study of mathematics.

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APPENDIX A: INTERVIEW INSTRUMENTS

Participant Participation Form

I,, agree to participate in a study involving the phenomenological examination of lived experiences with respect to undergraduate Mathematics courses. The study is being conducted by the researcher Brian Wood as part of his dissertation in Curriculum Design and Technology as part of the doctorate program through Keiser University.

I also hereby affirm I am at least the age of 25 years, having entered college to conduct undergraduate studies at the same age or later. The participant also acknowledges participation in the study is voluntary and the participant may leave the study at any time without any ramification to their studies conducted with Purdue University at any of the campuses.

This notice also hereby confirms participation in the study is conducted without any compensation involving two interviews and that all data collected is protected from release in any unencrypted form. The participants of the study are considered cohorts in the study and all information possibly utilizable for identification is protected, and available at any time with 24-hour notice. The participant also affirms the researcher Brian Wood has the rights to use the data collected as part of the research under the understanding all the data collected is protected in both audio and transcript forms.

Each participant may receive a copy of the final dissertation upon completion if so desired once notification is made to the researcher. Following completion of the dissertation and publication, any data collected during the study will be retained for one year upon which all records from the interviews is destroyed.

Brian Wood agrees to my participation in the study as defined by the conditions established above.

I hereby read, understand, and agree to participate in the study.

Participant Name:

Researcher Name

Date: _____

APPENDIX B: INTERVIEW QUESTIONS

Interview #1 Questions

Demographics

1. Please state your name and age.
2. At what level (undergraduate/graduate) have you studied Mathematics at Purdue University?
3. Were you a minimum age of 25 years when you entered as a student of Purdue University?

Categorizing

1. Are you a full time or part time student?
2. What is the minimum level of Mathematics you have studied at Purdue University?
3. What is your declared major at this time?

Emotional Association of Mathematics

1. Could you tell me your initial impression of Mathematics prior to taking your first collegiate Mathematics course? Please explain.
2. Has your initial impression changed or stayed the same since you have taken a collegiate level Mathematics course?

Conditional follow up question: If it has changed, how so?

3. What do you feel is the impression of others regarding the study of Mathematics?
4. A common comment by younger students in secondary education may be what use is studying Mathematics or when am I ever going to use this in life. How would you describe your impression of the relevancy of Mathematics? Please explain.
5. What stance do you have on the emotional attachment generated from studying Mathematics?

Opinions of Mathematical Education

1. Mathematics may be viewed by some students as being purely mechanical. For example, given X information, what can you tell me about Y? What portion of Mathematics education do you feel should be researched in greater detail for sake of clarity or to enhance relevance?
2. One university has ceased to teach Mathematics as part of their curriculum. At what point do you feel mathematical education ceases to be practical for the general public? Please explain.
3. Assuming you were studying graduate level Mathematics; at what point would you consider you have learned enough of Mathematics to be comfortable educating others?

Theoretical Perspective

1. If you were to assume the role of a Mathematics teacher or Professor, what particular aspect of Mathematics would feel is essentially for the general public?
2. Based upon your experiences studying Mathematics, what do you feel is essential in order for a student to be successful in studying Mathematics?
3. What do you feel is the greatest stumbling block for students who have difficulties studying Mathematics or relating to the study of Mathematics?
4. Scenario:
To date you have had experiences with Mathematics teachers and professors and their various teaching styles. As your lived experiences are unique to yourself, think back upon these experiences.

Opinions Regarding Mathematics (in general)

Now, if you were to assume the role of an educator, particularly with regarding to mathematics education, given your experiences in the past with regards to studying Mathematics, what aspect of the instruction would you consider monumental for the improvement of mathematical comprehension?

1. How would you describe the importance or lack of importance in studying Mathematics?
2. Assume for a moment that studying Mathematics serves a purpose. How would you describe the purpose?

Conclusion Question

At this point, do you have any questions regarding questions asked or the nature of the study?

APPENDIX C: DISTRIBUTION OF PROBABLE STEM COLLEGE MAJORS

Table 2: Distribution of Probable STEM College Majors

Biological Sciences	12.90%
Social Sciences	11.10%
Engineering	10.30%
Other Majors (including Technology)	5.60%
Mathematics and Computer Sciences	3.10%
Physical Sciences	<u>2.50%</u>
Total	45.50%

Source: Moakler, M. W., & Kim, M. M. (2014). College major choice in STEM: Revisiting confidence and demographic factors. *Career Development Quarterly*, 62(2), 128-142. doi:10.1002/j.2161-0045.2014.00075.x

Appendix D: Participant Categorizing

Table 3: Participant Demographic Information – Identifier | Age | Major

- | |
|---|
| <ul style="list-style-type: none">• Participant # 01 - 10 - 2016 - NC 39 Early Elementary Education• Participant # 02 - 10 - 2016 - NC 29 Early Elementary Education• Participant # 03 - 10 - 2016 - NC 47 Early Elementary Education• Participant # 04 - 10 - 2016 - NC 28 Early Elementary Education• Participant # 05 - 10 - 2016 - NC 36 Early Elementary Education• Participant # 06 - 10 - 2016 - NC 37 Early Elementary Education |
|---|

Note: Participant ages refer their age at the time of the interviews. Mean age of the participants is 36 years old.

Appendix E: Emotional Association of Mathematics

Table 4: Emotional Association of Mathematics – Question 1

Question: 1. Could you tell me your initial impression of Mathematics prior to taking your first collegiate Mathematics course?

<ul style="list-style-type: none"> Participant # 01 	<p>This is my second Bachelor's Degree. Prior to my time at Purdue, I was intimidated by Mathematics. I had had a poor experience in high school, which caused me to try to avoid Mathematics at all costs when pursuing my first Bachelor degree. Therefore, I took the minimum number of Mathematics courses needed; in fact, to obtain my first Bachelor's, I completed the math course that was intended for "Liberal Arts" majors (I majored in Social Work). I was dreading having to take mathematics courses this second time around.</p>
<ul style="list-style-type: none"> Participant # 02 	<p>I've always have had Math courses and I've for the most part have done well in them besides from Geometry. I was nervous about taking this Math class since I haven't had one in almost 10 years.</p>
<ul style="list-style-type: none"> Participant # 03 	<p>My prior experience with mathematics left me feeling apprehensive about studying it. My grade school and high school teachers were not invested in their student's development of a deep understanding of the subject. Their teaching approaches were sub-par at best.</p>
<ul style="list-style-type: none"> Participant # 04 	<p>I never had great experiences with Math but I have had some really great professors that made it easy.</p>
<ul style="list-style-type: none"> Participant # 05 	<p>I absolutely loathed math. I had a high school teacher that loved to make you feel stupid and I have hated math ever since I took her class.</p>
<ul style="list-style-type: none"> Participant # 06 	<p>Math is not an easy subject for me, making me uneasy.</p>

Table 5: Emotional Association of Mathematics – Question 2

Question: 2. Has your initial impression changed or stayed the same since you have taken a collegiate level Mathematics course?

- Conditional follow up question: If it has changed, how so?

• Participant # 01	I have become much more comfortable and confident in taking a math course. I no longer feel as if I have a “block” and am no longer intimidated by these courses.
• Participant # 02	In some ways, my opinion has changed with math and how to present it to children.
• Participant # 03	My initial impression has changed considerably, mostly due to the teaching of Dr. David Feikes at the Purdue Northwest Westville campus. He teaches his students that math is not magic, but rather a sense-making activity. Because of him, I no longer fear math. My approach to math went from “I can’t do this” and “I’m horrible at math” to approaching the subject with a healthy attitude.
• Participant # 04	Because of some great professors, I have had an increase in my confidence when it comes to my math ability.
• Participant # 05	I took two remedial math classes at the University of Memphis. Failed each class the first time around and then got an ‘A’ in each class the second time around. Sometimes it just takes me awhile to “get” it. I had the same teacher all four of those times and she started to crack my “math sucks-down with math” shell. Fast forward about a decade and I’m at Purdue North Central. I took Math 111 online and passed it. I still thought math sucked though. Then I took a math class that Dr. Feikes taught. After having taken two of his classes I won’t say I’ve joined the math love parade, but I no longer go into a cold sweat when a math problem is presented to me.
• Participant # 06	Since I began taking MA 137-139, geared toward teaching. It is explained differently and I am more comfortable.

Table 6: Emotional Association of Mathematics – Question 3

Question: 3. What do you feel is the impression of others regarding the study of Mathematics?

• Participant # 01	I believe that others also feel a bit intimidated by math courses.
• Participant # 02	Some people don't enjoy math and when you say to them I'm heading to a math course there like oh you're going to math I'm sorry.
• Participant # 03	I find a balance of attitudes, from negative to positive, regarding the study of mathematics.
• Participant # 04	Usually a pain and waste of time.
• Participant # 05	It's really hard to speak for others since we are all individuals and all have our own opinions. I believe people either love math, hate math, or don't care one way or the other.
• Participant # 06	Many people are nervous about Math and do not feel confident in their ability.

Table 7: Emotional Association of Mathematics – Question 4

Question: 4. A common comment by younger students in secondary education may be what use is studying Mathematics or when am I ever going to use this in life. How would you describe your impression of the relevancy of Mathematics? Please explain.

<ul style="list-style-type: none"> Participant # 01 	I believe that Mathematics is very relevant not only to my future profession of being an educator but also just in “everyday life.” Without an understanding of Mathematics, it would be difficult to do things like calculating taxes when shopping, calculating discounts, measuring, budgeting, etc.
<ul style="list-style-type: none"> Participant # 02 	It’s not that you are going to use this application but you’ll use the problem solving to find the solution.
<ul style="list-style-type: none"> Participant # 03 	The study of mathematics involves learning deeper problem-solving skills, which is vital in teaching children. As pre-service teachers, we must study all of the core subject areas in order to better teach our future students.
<ul style="list-style-type: none"> Participant # 04 	I always tell my 11-year-old that you will use math more than you realize. Having good math skills helps you have good problem solving skills as well as help you with every day activities like grocery shopping, budgeting, paying bills, leaving a tip, etc.
<ul style="list-style-type: none"> Participant # 05 	We all do math every day even when we don’t realize it. When you cook, and follow a recipe you are doing math. If you take medicine you need to know math to count out the right pills. We need math to tell time. Math is used in hospitals. Math is used at banks. Math is used pretty much everywhere.
<ul style="list-style-type: none"> Participant # 06 	We use Math every day. You have to know many more parts than you will use because it builds upon itself.

Table 8: Emotional Association of Mathematics – Question 5

Question: 5. What stance do you have on the emotional attachment generated from studying Mathematics?

• Participant # 01	No response.
• Participant # 02	No response.
• Participant # 03	My belief is that the emotional attachment that is generated from studying mathematics comes from our prior experiences, whether negative or positive. My prior stance (before college level) was a complete avoidance and feelings of negativity towards the subject. Now that I have had several positive experiences with the subject, I approach mathematics with more confidence.
• Participant # 04	I think that teachers need to work harder on their approach to teaching math and I think that this will help people feel less hatred towards math.
• Participant # 05	I think that there needs to be more teachers who encourage their students and less who make their students feel stupid. No one is stupid. Just because a student hasn't grasped a concept yet doesn't mean that student won't grasp the concept down the road.
• Participant # 06	It is great when you have a moment where you know you "get it."

Appendix F: Opinions of Mathematical Education

Table 9: Opinions of Mathematical Education – Question 1

Question: 1. Mathematics may be viewed by some students as being purely mechanical. For example, given X information, what can you tell me about Y? What portion of Mathematics education do you feel should be researched in greater detail for sake of clarity or to enhance relevance?

• Participant # 01	I believe that it should be further researched how teaching concepts and making math a “sense-making” activity affects students’ critical thinking and algebraic skills.
• Participant # 02	I feel that math is part equations and I think that I need to put an emphasis on the problem solving and how problem solving can be used in many different aspects of life not just math.
• Participant # 03	Algebra with real world applications should be researched greater. Understanding the process, not just memorizing the steps, should be a greater focus in the younger grades.
• Participant # 04	Geometry.
• Participant # 05	I really have no idea.
• Participant # 06	Short cuts are great.

Table 10: Opinions of Mathematical Education – Question 2

Question: 2. One university has ceased to teach Mathematics as part of their curriculum. At what point, do you feel mathematical education ceases to be practical for the general public? Please explain.

<ul style="list-style-type: none"> Participant # 01 	I believe that if one is not pursuing a career that directly involves the need to know and understand complex concepts of math, then there is no need to teach it beyond the basic concepts. For example, I am not certain the reasoning behind teaching trigonometry for example if this is not going to be utilized directly in one's field.
<ul style="list-style-type: none"> Participant # 02 	I think that it's kinda sad that they stopped teaching math I feel that math is such a part of our daily life it's something that is needed.
<ul style="list-style-type: none"> Participant # 03 	Mathematics does not cease to be practical for the general public at any level. It is a core subject that intertwines with all subject areas. Like all subjects, different levels are practical for different levels of need, and the desired outcome. We use Math every day. At what level is dependent on where you are in life; Student, high school math teacher, engineer, elementary school teacher, ironworker, at-home parent, attorney, etc.
<ul style="list-style-type: none"> Participant # 04 	I really do not think that there is much use beyond Algebra.
<ul style="list-style-type: none"> Participant # 05 	I don't think mathematics ever ceases to be practical. Most if not all of us use it every single day.
<ul style="list-style-type: none"> Participant # 06 	I don't understand not having Math as a part of any curriculum.

Table 11 Opinions of Mathematical Education – Question 3

Question: 3. Assuming you were studying graduate level Mathematics; at what point, would you consider you have learned enough of Mathematics to be comfortable educating others?

• Participant # 01	I am not certain that there is a point at which one could consider themselves having learned enough math to be comfortable educating others if you are pursuing graduate level Mathematics.
• Participant # 02	I feel that learning is continuous and you can keep going with it.
• Participant # 03	That would likely be dependent on what level and area I wanted to educate others in.
• Participant # 04	Trigonometry.
• Participant # 05	I'll be teaching grades three and younger. I'm comfortable now about my math skills in regards to teaching what children in those grades need to know. Now I am more interested in learning the methods for teaching math to children. As for teaching older students I would have to have many, many, MANY years of graduate level mathematics before I would even set a toe in say a high school classroom as a math teacher.
• Participant # 06	Everyone has their own point of understanding something thoroughly. I just want to be confident enough that I understand the material I am teaching.

Appendix G: Theoretical Perspective

Table 12: Theoretical Perspective – Question 1

Question: 1. If you were to assume the role of a Mathematics teacher or Professor, what particular aspect of Mathematics would feel is essentially for the general public?

• Participant # 01	Proportions, percentages, base ten understanding, basic algebraic concepts.
• Participant # 02	Problem solving it's something that we all need to be familiar with.
• Participant # 03	To approach mathematics as a problem-solving activity with a hands-on and real world approach which would include a foundation of number sense, computation, algebraic thinking, Geometry, measurement, data analysis, Statistics, and Probability.
• Participant # 04	Basic math as well as Algebra and Geometry.
• Participant # 05	Addition, subtraction, multiplication, division, and basic Algebra.
• Participant # 06	I feel that the general public most commonly uses percent's, fractions, and measurement.

Table 13: Theoretical Perspective – Question 2

Question: 2. Based upon your experiences studying Mathematics, what do you feel is essential in order for a student to be successful in studying Mathematics?

• Participant # 01	I believe that it is essential for a student to be able to make math a “sense making” activity as well as understanding basics such as number concept and base ten models.
• Participant # 02	I feel that you just need to do it and keep practicing it keep doing problems.
• Participant # 03	Based on my experiences, it is essential to approach mathematics as a problem-solving activity with a hands-on and real world approach. This should be taught by an educator with a deep belief in the fact that every student can understand mathematics if they are given the proper tools and knowledge to succeed.
• Participant # 04	Hands on practice not just paper work.
• Participant # 05	You need to understand what comes before something before you pursue what comes after something. Math skills build on each other and complement each other.
• Participant # 06	A teacher who can explain examples that make sense.

Table 14: Theoretical Perspective – Question 3

Question: 3. What do you feel is the greatest stumbling block for students who have difficulties studying Mathematics or relating to the study of Mathematics?

<ul style="list-style-type: none"> Participant # 01 	I believe that the biggest stumbling block for students having difficulties studying Mathematics or relating to the study or Mathematics, to be their past negative experiences with math as well as not fully understanding how what they are learning is meaningful to their future profession or everyday life.
<ul style="list-style-type: none"> Participant # 02 	That it's not how many problems you do but getting the basics down and getting to know the process on how to do it.
<ul style="list-style-type: none"> Participant # 03 	Educators who do not make mathematics relatable to their students is the greatest stumbling block for students. Like all subjects, mathematics should be taught with thought given to real-world applications.
<ul style="list-style-type: none"> Participant # 04 	I think that many teachers believe there is only one way to teach a concept so if you can't grasp the way that teacher is teaching the concept you will never understand it.
<ul style="list-style-type: none"> Participant # 05 	I think the greatest stumbling block are the mental blocks we place upon ourselves. Thinking such as "I can't do this" or "I'll never get this" hinders us.
<ul style="list-style-type: none"> Participant # 06 	Simply, not getting it before the teacher moves on.

Table 15: Theoretical Perspective – Question 4

Scenario: To date you have had experiences with Mathematics teachers and professors and their various teaching styles. As your lived experiences are unique to yourself, think back upon these experiences.

Question: 4. Now, if you were to assume the role of an educator, particularly with regarding to mathematics education, given your experiences in the past with regards to studying Mathematics, what aspect of the instruction would you consider monumental for the improvement of mathematical comprehension?

• Participant # 01	Making math applicable as well as meaningful to the students that are learning it. Also, helping to make math a “sense-making” activity rather than just a memorization process.
• Participant # 02	I have had a variety of teachers when it comes to math as well has my children I have a child in 3th grade and I see how he does math and different styles and methods that we are teaching to get the right information.
• Participant # 03	Hands-on experiences (the use of manipulatives).
• Participant # 04	One word: Differentiation.
• Participant # 05	Teach students the word “Yet”. Whenever they say they can’t do something that is hard for them say “yet”. I can’t add... yet”. I don’t get calculus...yet”. Also, if a student is struggling offer as much help as possible. Don’t make your student feel like a dunce.
• Participant # 06	Time in each section, building up with everyone gaining understanding and confidence.

Appendix H: Opinions Regarding Mathematics (in general)

Table 16: Opinions Regarding Mathematics (in general) – Question 1

Question: 1. How would you describe the importance or lack of importance in studying Mathematics?

<ul style="list-style-type: none"> Participant # 01 	I think that it is important to have a basic foundation of math. I believe that this is important in a lot of “everyday” life activities. I don’t believe though that study of very complex mathematical concepts is necessary if one will not be utilizing math in their chosen profession.
<ul style="list-style-type: none"> Participant # 02 	Math is important for the fact that it’s in so many different applications.
<ul style="list-style-type: none"> Participant # 03 	The studying of Mathematics is equally as important as studying Language Arts, Social Studies, Science, Art, Music, Engineering, Technology, and Physical Education. They are all parts to a whole experience.
<ul style="list-style-type: none"> Participant # 04 	I think studying math is important, as I said earlier, it not only helps you function as an adult but it also improves problem solving skills.
<ul style="list-style-type: none"> Participant # 05 	Math is very important. Even though I would love to say it isn’t I know that isn’t true. Math is everywhere. It is far from my favorite subject, but I do know it is important.
<ul style="list-style-type: none"> Participant # 06 	I feel that our nation needs to catch up to some areas of our world in our Math skills. It is one of the foundational subjects in education.

Table 17: Opinions Regarding Mathematics (in general) – Question 2

Question: 2. Assume for a moment that studying Mathematics serves a purpose. How would you describe the purpose?

• Participant # 01	To be able to utilize and apply mathematical concepts in the everyday activities such as figuring out budgets, discounts, percentages, taxes, making change, etc.
• Participant # 02	Its purpose is to embrace new ideas and ways to do things.
• Participant # 03	The purpose of mathematics is to learn how to problem-solve and make sense of real-world problems.
• Participant # 04	To improve upon problem solving skills.
• Participant # 05	Math helps us to advance society. If it wasn't for math we might never have flown to the moon, landed a rover on mars, or any of the other amazing things that require math.
• Participant # 06	It helps with problem solving, every day measurement, and building our world.