A PHENOMENOLOGICAL STUDY OF MATHEMATICS TEACHER EDUCATORS’ EXPERIENCES RELATED TO AND PERCEPTIONS OF STATISTICS

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The purpose of this study was to determine the experiences related to and perceptions of statistics of mathematics teacher educators. Particularly, this study focused on the participants’ lived experience by training preservice K-8 teacher candidates in topics related to statistics in the mathematics methods course. Their perceptions and interpretations were organized according to key points, respective to each semi-structured question presented in the interview protocol.

The participants for this study were three (3) mathematics teacher educators in the same state system of higher education in a northeastern state in the US. The mathematics teacher educators were interviewed individually for 60-90 minutes in a semi-structured format, discussing their experiences and perceptions of statistics related to their role as K-8 math methods professors.

The design of the study was phenomenological (Giorgi, 1994; Moustakas, 1994). Each question contained in the interview protocol was broken into key points, capturing the essence(s) of their experiences. The key points and interpretations were reviewed with Richard Busi, a doctoral student in mathematics education, in an effort to triangulate the interpretative process (Denzin, 1978). The results obtained from Chapter IV indicate three major domains discussed by the participants, including preservice teacher
preparation, conceptualizing the role of statistics, and allocation of time. This study also suggests that there are numerous factors related to the experiences and perceptions of mathematics teacher educators, which may promote a more thorough understanding of the challenges they face in light of preparing preservice teachers to teach mathematical and statistical notions.
DEDICATION

This dissertation is dedicated to my loving parents, Ronald J. Hogue and Nancy B. Hogue. In your own rights, you are the most loyal and selfless individuals that I know. I am so blessed to call you my parents. As I look back on my life, I am constantly reminded of just how much you loved and supported me. Only now as an adult can I, and do I, truly appreciate the selfless sacrifices that you made so that I had every opportunity imaginable. I find myself measuring my own success as an individual by the example that you have etched in my mind through years of simply being yourselves. Mom, you are one the most genuine individuals on earth; your affect, compassion, and morality are qualities that I will always strive towards. Dad, I respect you; your tenacity, decisiveness, and leadership have been exemplary and I promise to carry on the family name with pride and honor. Ultimately, we are all a product of our heritage and there is not a day that goes by when I am not reminded of what a tremendous family I have – from my incomparable grandparents to my unwavering aunts, uncles, and cousins. I have been truly blessed.
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The most persevering individual I know is my sister, Rachel. I respect the measure of devotion that you demonstrate to others and your genuine commitment to helping one person at a time. I truly appreciate all that you have stood for; all of the courage that you have found in your walk; and all of the heart and spirit that you live with. I love that I can always count on you, Rachel.

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CHAPTER I

INTRODUCTION

Data, information that is presented in a numerical form, breathes life into the ways in which consumers of such information are informed, while providing a framework for making educated decisions and grappling with uncertainty. In a society that is driven by technology, the rate at which data is infusing our lives is increasing at an enormous rate (Burrill & Elliott, 2006). Today’s youth are emerging consumers of data in every aspect of their lives. Citizens have myriad interactions with data daily – from opinion polls to medical research to millions of internet sites – all requiring critical discernment and the ability to interpret data. In today’s world, data are used to craft policies, make decisions, and modify preexisting constructs. Konold and Higgins (2003) speak to the need for a statistically-literate individual by stating that “For those who have traditionally been left out of the political process, probably no skill is more important to acquire in the battle for equity than statistical literacy” (p. 193).

Statistics has emerged as a profound stakeholder in the pre-kindergarten through grade 12 mathematics curriculum (e.g. Franklin & Garfield, 2006; National Council of Teachers of Mathematics [NCTM], 1989; 2000). International meetings such as the International Conference on Teaching of Statistics (ICOTS) provoked the United States to consider adopting a formal framework for statistics education in the presence that many European countries were well transitioned for the growing impetus for statistical
literacy (Shaughnessy, 2007). Gaining momentum from international initiatives and emerging calls from the academy, NCTM placed probability and statistics as a foundational area of content in their *Curriculum and Evaluation Standards* (NCTM, 1989). As Shaughnessy points out, “Prior to the Standards statistics had been a lost stepchild in mathematics curriculum frameworks, the mere frosting on any mathematics program if there was time at the end of the school year” (2007, p. 957).

The reform-based initiatives of NCTM have helped to activate research efforts and pioneer studies on the ways in which students think about statistics and the pedagogical implications for teaching students about data and chance. During this time of reform in mathematics education, synthesis and analysis of the literature in statistics education began to appear, providing a gateway and springboard for future study (e.g. Garfield & Ahlgren, 1988; Shaughnessy, 1992). From its infant beginnings, topics surrounding statistics have now burgeoned to significant bodies of research in curriculum and pedagogy (Jones, Langrall, & Mooney, 2007; Konold & Higgins, 2003; Shaughnessy, 2003; 2007) and publications aimed at reforming statistics education (Burrill, Franklin, Godbold, & Young, 2003; Gelman & Nolan, 2002; Groth, 2007; Shaughnessy & Chance, 2005).

National assessments for elementary and secondary students have demonstrated an increased focus on data analysis (e.g. National Assessment Governing Board [NAGB], 2009; Tarr & Shaughnessy, 2007). Results and implications from the National Assessment of Educational Progress (NAEP) indicate that students have shown improvements on data analysis items related to procedural understandings (Tarr &
Shaughnessy, 2007; Zawojewski & Shaughnessy, 2000a); however, Shaughnessy (2007) points out that conceptual tasks related to data analysis “languish behind their procedural counterparts” (p. 960). Such findings are certainly not unique concerns in the field of statistics education, since notions and degrees of understanding are certainly not novel concerns to the field of mathematics education (e.g. Brownell, 1947/2004; Skemp, 1976).

Comparing Statistics and Mathematics

The surge of research on the teaching of statistics at the pre-K–12 level is attributable largely in part to findings from research in mathematics education (Garfield, 1995). Further, policy has driven an increased emphasis of quantitative reasoning on the grounds of informed citizenship and decision-making skills (e.g. NCTM, 2000). To this end, the prevailing content in school statistics curriculum has departed from simply reporting the mathematical outcomes of statistical ideas to a focus on the use of authentic data, concepts, technology, and thinking strategies (delMas, 2004). However, as Scheaffer (2006) contends, the interpretative nature of statistical reasoning contrasts with mathematical reasoning, signaling that measures must be taken to ensure the development of statistical reasoning in a prevailing curricula largely dominated by mathematics.

The academic positioning that statistics maintains is different from mathematics, since the former is a methodological discipline while the latter is a core discipline (Cobb & Moore, 2000). As such, statistics is held as a discipline that maintains a similar relationship to the foundational tenets of mathematics as other disciplines, such as
physics and economics. As Manaster upheld, “Using data to make decisions is rather
different from the science of numbers and shapes” (as cited in Steen, 2004, p. 67). While
their respective academic spaces may appear in some ways unrelated, statistics relies
heavily upon the mathematics that undergirds much of its theory. According to
Scheaffer, statistics and mathematics “Each can support the other and both can become
stronger as a result, but they should not be merged into one” (2006, p. 320).

A significant area of distinction occurring between statistics and mathematics is
the role of context. Context surrounds statistics; understanding, describing, and
measuring data embodies much of the situated complexity amidst the inference and
interpretation process. In mathematics, however, the context of many problems is most
commonly stripped off or removed in place of abstraction, proof, and generalization.
Similarly, statistics and mathematics ask different types of questions and reach different
types of conclusions. The deductive nature of mathematics oftentimes arrives at an
indisputable truth, while the inductive reasoning of statistics is justifiable, yet not proof-
based. Thus, conclusions in statistics are enveloped by phrases such as “the data suggest
that …” not “the data prove that …” As such, Rossman, Chance, and Medina (2006)
maintain that statistics education requires disciplined, distinct preparation of teachers
because teaching statistics requires different types of instructional preparation and
students respond differently to statistics than to mathematics.
Pedagogical Content Knowledge

There has often been a strong perception that student achievement operates in conjunction with teacher content knowledge and his or her ability to articulate teaching strategies to elicit conceptual understanding of students through learning tasks (Wilson, Floden, & Ferrini-Mundy, 2002). Thus, Darling-Hammond stated, “what teachers know and do is one of the most important influences in what students learn” (1998, p. 6). The research of Hill, Rowan, and Ball (2005) supports this widely accepted view that teachers’ knowledge of content can positively influence student achievement and performance in mathematics. In a related sense, researchers hypothesize that students’ understandings of statistical concepts may be related to teachers’ lack of experience with statistical content, upholding that most teachers have few statistical experiences (Reading & Shaughnessy, 2000).

The significance of the aforementioned studies rests directly in the writings of Shulman (1986, 1987a, 1987b). Shulman (1987a) identified seven types of teacher knowledge: (1) content knowledge; (2) general pedagogical knowledge; (3) curriculum knowledge; (4) pedagogical content knowledge (PCK); (5) knowledge of learners and their characteristics; (6) knowledge of educational contexts; and (7) knowledge of educational ends, purposes, and values (p. 8). As the pioneer of PCK, Shulman stated that while typical assessments of teachers target particular skills (e.g. finding the arithmetic mean from a variety of data sets and contexts), theses inquiries should be grounded in the “applications of pedagogy to specific subject areas” (1987b, p. 41).
The significance of pedagogical content knowledge is championed in the *Professional Standards for Teaching Mathematics* (NCTM, 1991), proclaiming that “teachers of mathematics should develop their knowledge of the content and discourse of mathematics, including mathematical concepts, procedures, and the connections among them…” (p. 132). Knowing how to establish these relationships and forging students’ statistical maturation appears to lie at the center of PCK, while also providing a strong call for research (Tirosh, 2000; Watson, 2001). The notion of PCK, founded initially in mathematics instruction, is also advanced in the context of statistical education topics by Groth (2007) and Watson, Callingham, and Donne (2008).

**Teacher Preparation in Statistics Education**

It has been an accepted notion that the preparation of mathematics teachers is the joint responsibility of mathematics educators and mathematicians, manifested in pedagogy and content coursework, respectfully (Monk, 1994). Statistics educators maintain that the development and sequencing of courses and the relationships between professional organizations indicate the crosscutting boundaries between colleges of education and colleges of natural science (Franklin & Mewborn, 2006). These authors indicate that it is of increasing importance that two additional stakeholders – statisticians and statistics educators – join this dialogue in order to drive teacher preparation initiatives according to the expectations of the *Principles and Standards of School Mathematics (PSSM)* (NCTM, 2000).
The Mathematical Education of Teachers (MET) report, advanced by the Conference Board of the Mathematical Sciences (CBMS) (2001a), echoes the call of the NCTM for an increasing emphasis on data analysis and statistics. The MET report opines that all stakeholders – teacher educators, mathematicians, and statisticians – should assume a collaborative role in the education of mathematics teachers. Researchers (e.g. McClain, 2005), professional associations (CBMS, 2001a), and curriculum developers (Chance & Rossman, 2006) maintain that teachers need occasions to experience the study of statistics in ways that are similar to how they would be expected to deliver and develop the content in their own classrooms. While researchers are unearthing questions related to the learning experiences that support teachers’ knowledge of statistical ideas (e.g. Franklin & Mewborn, 2006; Hammerman & Rubin, 2004; Makar & Confrey, 2004), they hold that exposing the experiences that guide teachers to strong understandings of statistical concepts poses a challenging task.

Research in teacher education programs strongly hold that carefully crafted educational experiences must take place in order to develop preservice teachers’ conceptual understanding of mathematical phenomena (Ball, 1998; Ball & Bass, 2000; Ball, Lubienski, & Mewborn, 2001; Manouchehri, 1997). To achieve such ends, Ball upholds that content knowledge of mathematics and perpetual understandings of mathematical inquiry are critical components to the teaching and learning process (Ball, 1998; Ball & Bass, 2000). Teachers with a deep conceptual grounding in mathematics and statistics are better able to provide analogies, relationships, unification, and clarification within pedagogical models, thus making mathematics learning more
effective and efficient (Grouws & Shultz, 1996). As Shaughnessy (1992) emphasizes, “The success of the NCTM’s ambitious standards recommendations will ultimately depend upon teachers” (p. 489).

**Conceiving Meaningful Data Tasks - The Arithmetic Mean**

The arithmetic mean, colloquially referred to simply as the mean in most K-8 applications, presents a purposeful glimpse into the conception of learning tasks related to data analysis. While there are numerous measures of center (mean, median, mode, midrange), the arithmetic mean is the only such measure that has implications reaching beyond a statement of central tendency. The arithmetic mean is employed when performing numerous statistical calculations, such as the standard deviation of a data set, hypothesis testing, and defining confidence intervals. As Pollatsek, Lima, and Well (1981, p. 191) contended, ordinary consumers of information conceptualize the mean “in such guises as cost-of-living and stock market indices and estimated proportions of people approving governmental policies.”

Historically, the arithmetic mean has been taught as an algorithm before students forge conceptual understanding (Morrow & Kenny, 1998; Pollatsek, Lima, & Well, 1981). Thus, teachers and followers of the “mindless mimicry mathematics” (National Research Council, 1989, as cited in Battista, 1994, p. 466) tradition employ the oft used procedure of “add –‘em–up–‘n–divide” to solve problems that ask for an average, typical value, center, or mean with little or no conceptual grounding (Jacobbe, 2008).
NCTM specifically addresses the significance of students possessing a strong conceptual model of the arithmetic mean. Teachers are delineated with the task of assigning meaning to this important statistical notion. “Students often fail to apprehend many subtle aspects of the mean as a measure of center. Thus, the teacher has an important role in providing experiences that help students construct a solid understanding of the mean…” (NCTM, 2000, p. 250). To this end, numerous research studies have been published (e.g. Jones, Thornton, Langrall, Mooney, Perry, & Putt, 2000; Konold & Pollatsek, 2002; McClain & Cobb, 2001; Mokros & Russell, 1995; Watson & Moritz, 2000a; Watson & Moritz, 2000b), treatises have been advanced (e.g. Cortina, 2002; Cortina, Saldanha, & Thompson, 1999; Gal, 1998; Garfield, 1995; Scheaffer, Watkins & Landwehr, 1998), and practitioner articles (e.g. Uccellini, 1996; Zawojewski & Shaughnessy, 2000b) have been rendered in order to advance methods of conceptualizing how the arithmetic mean is taught and learned. The abovementioned studies and others will be synthesized in Chapter II.

**Overview of Study**

Research has been conducted on the ways in which elementary and junior high school students (e.g. Mokros & Russell, 1995), high school students (e.g. Groth, 2005), college students (Marnich, 2008), preservice teachers (Groth & Bergner, 2006), and even experts (i.e. an engineer, mathematician, statistician) (MacCullough, 2007) negotiate tasks related to data analysis. Many of these studies were qualitative in nature, drawing
upon descriptive measures to capture participants’ understanding of these elementary concepts. Furthermore, MacCulloch’s (2007) study clearly advances the idea that presuming that one possesses expertise with the conceptual aspects of statistics and data analysis ideas (e.g. mean, median, etc.) is an unfounded conclusion when understanding is challenged through perturbation and questioning.

As Darling-Hammond (1998) emphatically proclaimed, students are only as capable as their teachers’ mathematical abilities. Teaching statistics requires a particular skill set which, while having a foothold in the mathematical sciences, requires the ability to interpret the context of data and interact with variability – notions with which educators traditionally trained using rote algorithmic procedures do not inherently possess (Franklin & Mewborn, 2006). It may be opportune to assume that strong data analysis skills are forged in elementary mathematics teacher preparation courses in colleges and universities; however, outside of the prevailing use of many statistical notions (take for example the arithmetic mean, in general, $x = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$) advanced in many courses, there are large disparities in their level of development in and of themselves (Konold & Pollatsek, 2002). Thus, presuming that fundamental statistical and data analysis notions are rigorously developed as a central tenet of preservice teachers’ methods coursework cannot be responsibly advanced if the explicit goal of a statistics education is to introduce students to more conceptual understanding of statistical phenomena (Franklin & Mewborn, 2006). In fact, recent research shows that data analysis and probability concepts are underrepresented in school curricula, perhaps
challenging their presence and development in preservice mathematics methods and content curricula (Tarr et al., 2008). Further, Shaughnessy asserts that “To date, far more research has been conducted in students’ understanding of statistics concepts than in teachers’ knowledge and practices…” (2007, p. 960).

This dissertation has reported on the experiences and perceptions of preservice teacher educators related to the statistics reform movement. The nature of the questions utilized in this study has attempted to make clear the experiences, understanding, and instructional decisions of kindergarten to grade eight teacher educators who instruct mathematics education methods and/or content courses at the tertiary level. Because of the significant impact that (mathematics) teacher educators have on preservice teachers, it is of utmost importance that there is a robust vision and articulation of the means, methods, and experiences that these individuals enact within their courses. Teaching methods courses create an environment for critical experiences targeted at shaping a viable skill set of instructional outcomes within the preservice experience. Ultimately, the teaching and learning frameworks captured within mathematics methods courses must embody topics related to data analysis in such a way that positively impact the educative experiences of the preservice teachers’ future students in the kindergarten through eighth grade classrooms.
Significance of Study

It is abundantly clear that students in elementary mathematics methods courses should be exposed to strategies and content aligned with *PSSM* (NCTM, 2000), state mathematics standards (e.g. Ohio Department of Education (2001)), and standards of accreditation (i.e. the National Council for the Accreditation of Teacher Education [NCATE], 2007). Within the constructs of this belief lies the notion that teachers should be guiding their students through standard-based instruction that is aligned with pedagogically sound methods (Stein, Smith, Henningsen, & Silver, 2000). And while pre-K–12 teachers have been studied regarding aspects of their statistical knowledge (Peters, 2009), there is no line of work that has specifically addressed mathematics teacher educators’ experiences with and perceptions of statistical and data analysis reform as it relates to their curricular and instructional decisions. Instructors and professors in colleges and departments of education who teach prospective elementary school teachers in mathematics methods and related courses have not been investigated to this point in the literature regarding their personalized experiences and perceptions of data analysis concepts in preservice methods courses.

Furthermore, institutional differences account for another variable that is unique to mathematics and science methods courses for preservice teachers (Judy Werner, personal communication, April 1, 2010). According to Werner, some mathematics methods courses for elementary school preservice teachers are taught in colleges and departments of education by education faculty, while others are taught in departments of
mathematics by mathematicians and mathematics instructors. This difference, while seemingly insignificant, may reveal differences in the way that professors of elementary school mathematics methods courses have experienced and perceive concepts related to data analysis in terms of teaching and learning frameworks.

This dissertation is grounded in the extensive research conducted by Tarr, et al. (2008) which found that content related to data analysis and probability has been underrepresented in the enacted school mathematics curricula. Further, Cooney (1999) reports data to support the notion that preservice teachers are deficient in their fluid understandings of topics traditionally taught in school mathematics, despite the fact that many realized much success in studying high-level mathematics at the undergraduate level. Hill, Rowan, and Ball (2005) expands upon Cooney’s work and state that “teacher preparation and job experience are poor proxies for the kinds of teacher knowledge and skill that in fact matter most in helping students learn academic content” (pp. 374-375).

Thus, beyond the capacity of content knowledge lingers a fundamental question of the perception of reform as it relates to a largely underrepresented area of the school mathematics curricula.

In short, assuming that teachers (and in the case of this research preservice teacher educators) possess the experiences and perceptions significant in helping their students learn fundamental data analysis and statistics notions is imprudent when so little investigative work has taken place within this domain in the past. Rather, investing how preservice teacher educators discuss and perceive their personal vision map of data analysis topics in their mathematics methods course will provide a glimpse into the ways
of representing and knowing of a small, yet purposeful, sample. Understanding such foundational notions of how statistics and data analysis topics are perceived by elementary mathematics methods professors undergirds the advancement of statistics education, both at the university and kindergarten through eighth-grade levels. By investigating the ways in which fundamental notions related to data analysis are experienced and perceived by preservice teacher educators in mathematics methods courses, the literature base will be extended and a new field of research may expand, namely that of researching the ways in which teacher educators perceive their experiences and understandings related to topics of statistics and data analysis, and how this knowledge may be subsequently manifested in curricular and instructional decision making models. With this established, it is important to state the overarching goal of this study was to better inform the undergirding experiences and perceptions of preservice mathematics educators related to statistics and data analysis topics. It is hoped that this study may open dialogue for best practices among mathematics and statistics educators in courses related to preservice and inservice teacher education. Further, this study, along with others in the future, may better inform curriculum modification, professional development, and enrichment for preservice teachers, inservice teachers, and mathematics and statistics educators.
Research Questions

This research study was designed to answer the following questions with respect to the sample defined in chapter III:

1. What are the experiences of preservice mathematics teacher educators related to statistics?
2. What are the perceptions of preservice mathematics teacher educators related to conveying statistical notions in the K-8 math methods class?
CHAPTER II

REVIEW OF LITERATURE

Data, information that is presented in a numerical form, breathes life into the ways in which consumers of such information are informed, while providing a framework for making educated decisions and grappling with uncertainty. In a society that is driven by technology, the rate at which data is infusing our lives is increasing at an enormous rate (Burrill & Elliott, 2006). Citizens have myriad interactions with data daily – from opinion polls to medical research to millions of internet sites – all requiring critical discernment and the ability to interpret data. In today’s world, data are used to craft policies, make decisions, and modify preexisting constructs. Konold and Higgins (2003) speak to the need for a statistically-literate individual by stating that “For those who have traditionally been left out of the political process, probably no skill is more important to acquire in the battle for equity than statistical literacy” (p. 193).

Statistics has emerged as a profound stakeholder in the pre-kindergarten through grade 12 mathematics curriculum (e.g. Franklin, et al., 2005; National Council of Teachers of Mathematics [NCTM], 1989; 2000). International meetings such as the International Conference on Teaching of Statistics (ICOTS) provoked the United States to consider adopting a formal framework for statistics education in the presence that many European countries were well transitioned for the growing impetus for statistical literacy (Shaughnessy, 2007). Gaining momentum from international initiatives and
emerging calls from the academy, NCTM placed probability and statistics as a foundational area of content in their *Curriculum and Evaluation Standards* (NCTM, 1989). As Shaughnessy points out, “Prior to the *Standards* statistics had been a lost stepchild in mathematics curriculum frameworks, the mere frosting on any mathematics program if there was time at the end of the school year” (2007, p. 957). Replacing the *Curriculum and Evaluation Standards*, the *Principles and Standards of School Mathematics* (NCTM, 2000) provided a refreshed commitment to data analysis and probability. Some five years after the latter’s publication, the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report (Franklin, et al., 2007) set a new course for accountability and advancement in statistics education.

The reform-based initiatives of NCTM and the American Statistical Association have helped to activate research efforts and pioneer studies on the ways in which students think about statistics and the pedagogical implications for teaching students about data and chance. During this time of reform in mathematics education, synthesis and analysis of the literature in statistics education began to appear, providing a gateway and springboard for future study (e.g. Garfield & Ahlgren, 1988; Shaughnessy, 1992). From its infant beginnings, topics surrounding statistics have now burgeoned to significant bodies of research in curriculum and pedagogy (e.g. Jones, Langrall, & Mooney, 2007) and publications aimed at reforming statistics education (e.g. Burrill, Franklin, Godbold, & Young, 2003).

National assessments for elementary and secondary students have demonstrated an increased focus on data analysis (e.g. National Assessment Governing Board, 2009).
Results and implications from the National Assessment of Educational Progress (NAEP) indicate that students have shown improvements on data analysis items related to procedural understandings (Tarr & Shaughnessy, 2007; Zawojewski & Shaughnessy, 2000a); however, Shaughnessy (2007) points out that conceptual tasks related to data analysis “languish behind their procedural counterparts” (p. 960). Such findings are certainly not unique concerns in the field of statistics education, since notions and degrees of understanding have been at the forefront in the field of mathematics education for quite some time (e.g. Brownell, 1947/2004; Skemp, 1976).

The intention of this chapter is to assemble a beginning literature base for a research study aimed at capturing the perceptions of elementary education mathematics methods professors related to their articulation of the statistical knowledge necessary to teach at the elementary school level, as well as course documents used in their classes which may triangulate their claims. This chapter will be divided among several sections which will discuss past treatises and research relevant to this general question, serving ultimately as a launching point for this dissertation research.

The historical context and seminal works of Lee S. Schulman (1986; 1987a; 1987b) will be detailed in the first section of this chapter. Particularly, Schulman’s coined phrase, pedagogical content knowledge, will assist in framing the chapter by defining a space that merges knowledge of content with knowledge of pedagogy, while research from several of Schulman’s protégés will detail further advances into the field of mathematics and statistics education.
The next section will discuss the similarities and differences between mathematics and statistics, which will surface and discuss a distinct skill sets required for teachers and teacher educators when developing topics related to statistics and data analysis in the classroom. This section will reveal that much of the departure in statistics and data analysis from its mathematical brother is due largely to the differences between the deductive nature of mathematics and the inductive nature of statistics and data analysis.

The concluding portions of this chapter will detail research related to the knowledge required to teach statistics and data analysis. The knowledge required to teach statistics will be linked to the foundations of reform-based mathematics instruction; however, differences will be treated and discussed in particular to the difference persisting in statistics teaching and learning.

**Pedagogical Content Knowledge and Mathematics Knowledge for Teaching**

This portion is divided among two sections, from a general conceptualization of a specialized knowledge of teaching (pedagogical content knowledge) to a particular vision of the particular skills one must possess for teaching mathematics (mathematics knowledge for teaching). First, it is imperative to gather a conceptualization of the seminal writings of Schulman as he discussed pedagogical content knowledge. Then, treatment will be extended to the writings to Ball and colleagues within the scope of mathematics knowledge for teaching.
Schulman and Pedagogical Content Knowledge

Lee S. Schulman provided the ethos for much of preservice and inservice research that has engendered mathematics education reform, advancing the idea that there are particular skills required to effectively deliver content in an educative setting (e.g. Hill, Rowan, & Ball, 2005). Surprisingly, perhaps, is the fact that Schulman made a case for pedagogical content knowledge around the notion of defining the act of teaching as a profession that requires a disciplined, specific, and highly skilled understanding of the interaction between the content and the learner(s).

Schulman contended that if teaching were to be considered a profession, there must be standards by which the act of teaching has a distinct knowledge base separate from a general knowledge of the content itself. Schulman defined such a knowledge base for teaching as “a codified or codifiable aggregation of knowledge, skill, understanding, and technology…as well as a means for representing and communicating it” (1987a, p. 4).

Through the extended observations of teachers in practice, Shulman witnessed the difficulty that many novice teachers held as they provided instruction on particular topics, whereas more skilled teachers calculatingly delivered much more effective educative outcomes. Such a disparity, according to Shulman, was not necessarily a progressive result of experience, but rather a lack of rigorous examination within the rank and file of teacher preparation and certification programs. He stated:

The actions of both policymakers and teacher educators in the past have been consistent with the formulation that teaching requires basic skills, content knowledge, and general pedagogical skills…In this manner, I would argue,
teaching is trivialized, its complexities ignored, and its demands diminished.  
(1987a, p. 6)

Shulman’s perception indicated that a significant level of discipline is inherently involved in the teacher educative practices. Developing such a robust framework for teacher education, then, is not fostered amidst the likes of mimicry-based tasks, but rather in those authentic learning opportunities that legitimize and honor the nature and complexity in which the practice of teaching abounds (1987b).

In such a view, teaching necessarily begins with the idea that teachers must possess the ability to demonstrate and/or represent ideas in a way that lends knowledge and understanding to the less skilled student. In order to achieve such ends, it is the role of the teacher to envision the ends of their instruction through multiple mediums of consideration and understanding. The lesson outcomes should then be embodied through the masterful craft of enacting a series of events, activities, and opportunities that lead students to an emergence of a more refined way of thinking and knowing. The praxis of teaching, according to Shulman, is not honored by stating that knowledge is evoked through general teaching practices informed through knowledge of pedagogy (how to teach) and content knowledge of (what to teach), but rather teacher knowledge should be organized and defined in ways that are specific and exacting. Thus, Shulman defined the following categories to more completely detail the knowledge required for teaching, thus refining the how and what of teaching:

- content knowledge;
- general pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter;
• curriculum knowledge, with particular grasp of the materials and programs that serve as “tools of the trade” for teachers;
• pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding;
• knowledge of learners and their characteristics;
• knowledge of educational contexts, ranging from the workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures; and
• knowledge of educational ends, purposes, and values, and their philosophical and historical grounds. (1987a, p. 8)

Pedagogical content knowledge is worthy of special distinction in this study as it distinguishes the amalgam of how instructional concepts and content are sequentially unified. Shulman maintained that pedagogical content knowledge is “the category most likely to distinguish the understanding of the content specialist from that of the pedagogue” (1987a, p. 8).

Teaching then, is a strategic marriage between the subject matter, the conceptual organization of content, and fundamentals of inquiry that speak to the key understandsings that are necessary for learning of a topic and the ways in which students’ conceptions can be orchestrated in order to advance understanding. Thus, Shulman implied that it is imperative that teachers not only have a robust command of the material that they are teaching, but also have a thorough understanding of the ways in which students’ former understandings can be used as a scaffold for newly acquired, more thorough understandings. Similarly, it is of utmost importance that teachers are equipped with the ability to account for differences in students’ learning abilities and prior knowledge by engaging multiple methods of presentation and representation within the instructional model.
While it may appear convenient and oftentimes commonplace to refer to teaching strategies and best practices as a safe harbor for preservice education, Shulman (1987a, p. 11) warns that “The great danger occurs, however, when a general teaching principle is distorted into prescription, when maxim becomes mandate…” Thus, it is increasingly important to frame this research study within the context of the understanding of experience in particular to the participants involved. As such, the “wisdom of practice” has profound implications to discovering the experiences of those that have been acutely involved within the teaching and educative contexts pertaining to the particulars under investigation (Shulman, 1986). It is the goal of this study to render clear the experiences and, in Shulman’s words the “wisdom of practice” of those mathematics teacher educators in terms of the way that they perceive and discuss the knowledge required to teach statistics and data analysis at the elementary school level.

**Mathematics Knowledge for Teaching**

Schulman’s (1986; 1987a; 1987b) conceptualization of pedagogical content knowledge offered a significant springboard for Deborah Ball and her colleagues as they sought to forge a path of particular skills and understandings necessary for the teaching of mathematics (Ball, 2000; Ball, 2002; Ball & Bass, 2000; Ball, Hill, & Bass, 2005; Ball, Thames, & Phelps, 2008; Hill, Ball, & Schilling, 2008). The writings of Schulman and Ball and her colleagues were both similar in so far as discussing the specialized knowledge necessary to teach effectively, while underscoring the high level of fidelity necessary to merge content and instructional practice.
However, from a mathematical lens, Ball and colleagues extended Schulman’s conceptualization of pedagogical content knowledge in numerous ways. First, Ball and her colleagues provided a breadth of research that contributes specifically to the mathematical knowledge required for teaching elementary school and honors the “thickets of difficulty [students] and their teachers meet, even in what many consider to be ‘elementary’ content” (Ball, 2002, p. 5). Next, Ball and colleagues strongly contend that research on the knowledge necessary to teach mathematics must be grounded in active observations and research of students authentically involved in learning mathematics in order to define the understandings and misunderstandings they possess. To this end, they argue that students’ thinking processes should be analyzed and thoroughly understood within the context of authentic learning, in order to develop an informed model of the knowledge required to teach mathematics. Finally, Ball and colleagues disaggregated their conceptualization of mathematical knowledge for teaching into categories which holistically comprise this larger notion (Figure 1).
The domain map of the mathematical knowledge for teaching (Figure 1) demonstrates the marriage of subject matter knowledge and pedagogical content knowledge. The right side of the map, knowledge of curriculum, knowledge of content and students, and knowledge of content and teaching, reside within the conceptualization of Schulman’s pedagogical content knowledge. Knowledge on the pedagogical content knowledge region of the map includes the notions of the teacher’s understanding of curriculum materials, ability to interpret students’ misunderstandings and incomplete thinking, capability to build on students’ understandings, and ways of best sequencing instruction (Hill, Ball, & Schilling, 2008).

The left region of the domain map includes areas that lie outside of Schulman’s conceptualization of pedagogical content knowledge. Common content knowledge is best described as the mathematical knowledge and ability of a learned adult. As Hill,
Ball, and Schilling (2008) contend, common content knowledge is “knowledge that is used in the work of teaching in ways in common with how it is used in many other professions or occupations that also use mathematics” (p. 377, emphasis by authors). Such knowledge would include the ability to use mathematical notation and work problems similar to student tasks. The other primary conceptualization advanced in left region of the domain map includes specialized content knowledge, defined as “the mathematical knowledge that allows teachers to engage in particular teaching tasks, including how to accurately represent mathematical ideas, provide mathematical explanations for common rules and procedures, and examine and understand unusual solution methods to problems” (Hill, Ball, & Schilling, 2008, p. 377, emphasis by authors). The domain map and the work of Ball and her colleagues will prove to be beneficial as the conceptions of the statistical knowledge for teaching in elementary school is considered.

A Comparison of Statistics and Mathematics Education

Throughout the course of referencing literature related to statistics education, it is beneficial to first determine the differences between statistics and mathematics from methodological and educational lenses. In order to effectively propose a framework for statistical knowledge required for teaching, the assumptions and understandings inherent between mathematics and statistics must be explicitly addressed (Groth, 2007). Throughout this study, as Garfield (1995) upheld, it is important to understand that
statistics taught in a pre-K–12 setting has not sought emancipation from mathematics for self-fulfilling reasons undergirded by an explosion in mainstream popularity; rather, it is the nature and means of the discipline which require it to be distinguished and treated in ways which are largely unfamiliar for those trained in the traditional ways and methods of mathematics (Cobb & Moore, 1997).

In fact, it is extremely apropos for statistics to pay tribute to mathematics (Scheaffer, 2006). If one were to consider much of what is taught in school mathematics, many of the ideas are millennia old (e.g. geometry, algebra, trigonometry, proof). The core discipline of mathematics has offered to statistics, in varying degrees depending on the statistical ideas in reference, a source of methodological grounding. In short, many of the advances that continue to be made in statistics have been made from the theoretical benevolence of mathematics. And, while some question the role of mathematics in a progressive statistics education (e.g. Bullock, 1994, as cited by Cobb & Moore, 1997), Cobb and Moore (1997) strongly contended “But although statistics cannot prosper without mathematics, the converse fails” (p. 803).

Rossman, Chance, and Medina (2006) opined that “Statistics is a mathematical science” (p. 323). This definition is justified by the authors’ positions that statistics is a significant field of study, not simply numbers floating at free will; statistics makes much use of mathematics, yet it is a distinct discipline and should not be considered a branch of mathematics; and statistics is the science of gaining insight from data. Such a definition and a representation of the two disciplines renders a clear picture that statistics is not a departure from mathematics grounded in methodological differences; rather, the
questions that each seek to answer and the truth that is sought exists in simply different arenas (Scheaffer, 2006). Cobb and Moore (2000) more generally refer to mathematics as a core discipline, perceived, using the words of Gauss “the Queen of the Sciences,” while statistics is a methodological discipline, undergirded by the “Queen’s” theoretical backbone.

A tremendous area of distinction that exists between statistics and mathematics is the notion of context. Context embodies statistics; understanding, describing, and measuring data defines the situated complexity in the descriptive, interpretive, and inferential processes. Cobb and Moore (1997) articulately discussed the role context assumes in statistics and mathematics education:

Although mathematicians often rely on applied context both for motivation and as a source of problems for research, the ultimate focus in mathematical thinking is on abstract patterns: the context is part of the irrelevant detail that must be boiled off over the flame of abstraction in order to reveal the previously hidden crystal of pure structure. *In mathematics, context obscures structure.* Like mathematicians, data analysts also look for patterns, but ultimately, in data analysis, whether the patterns have meaning, and whether they have any value, depends on how the threads of those patterns interweave with the complementary threads of the story line. *In data analysis, context provides meaning.* (p. 803, emphasis by authors)

To demonstrate the notion of context, take for example a case presented in Moore and McCabe’s textbook *Introduction to the Practice of Statistics, 2nd Edition* (1993, p. 132). In the scatter plot that follows, the age (in months) a child first speaks is plotted with respect to his or her score on a Gesell aptitude test taken later on in life.
At first glance of Figure 2, one would be likely to presume that a strong negative correlation exists between variables, suggesting that a large value of one variable (age of first speaking) tends to relate to a small value of the other variable (Gesell score). In fact, the least-squares regression line supports this presumption and renders the slope of the line statistically significant ($p$-value = .002, $r^2 = .410$). However, on closer inspection, the negative association of the data is largely influenced by two extreme cases in the bottom right of the scatter plot. The question that reigns supreme in this case is whether one should discount these two outlying points. In order to discount these points, one must consider the context of the data. It turns out that these two children took a very long time to speak (one a bit longer than two years and the other about three and one half years) and also had extremely low aptitudes as measured by the Gesell aptitude test. In order to establish whether such a relationship may hold with more “typical” children, one would remove the two outlying data points given the context and nature of the problem.
Observing the scatter plot in *Figure 3*, scaled without the outlying values, conveys a very different story than the plot presented in *Figure 2* which included the outlying values. After a least-squares regression line is fitted to the modified scatter plot, there is virtually no association between the variables and the slope coefficient no longer renders the relationship statistically significant ($p$-value $= .890$, $r^2 = .001$).

As this example demonstrates, fitting a line to these data without considering the context of the problem would have unjustly rendered our presumption that a relationship between the data exists. Thus, as others have argued (e.g. Shaughnessy, 2006; Rossman, Chance, & Medina, 2006), context breathes life into the interpretive aspects and contextual landscape of the study of statistics. Statistics and data analysis activities, as delMas (2004) argues for, must depart from reporting mathematical outcomes of statistical ideas to focus on the use of authentic data, concepts, technology, and thinking strategies.
Wild and Pfannkuch (1999) vividly upheld the importance of context knowledge in the statistical investigative process by stating, “The arid, context-free landscape on which so many examples used in statistics teaching are built ensures that large numbers of students never even see, let alone engage in, statistical thinking” (p. 228). Statistics champions, by in large, a contextually rich, inductive process of building understandings and gaining insight from authentic data, whereas mathematics is deductive in nature, honoring the traditions of proof, generalization, and abstraction (Moore, 1997). This difference has a tremendous impact on the way in which statistics is taught. Cobb and Moore (1997) argued that “To teach statistics well, it is not enough to understand the mathematical theory; it is not even enough to understand also the additional, non-mathematical theory of statistics” (p. 803). Rather, teachers of statistics must possess the ability to meaningfully engage students in their development of making critical judgments about data; help students come to terms with the notion that the only certainty in statistics is the presence of variability; and understanding that the deterministic methods of mathematics are replaced by data in the form of interconnected systems and processes (Scheaffer, 2006).

The Standards

This particular section will address three major documents and/or initiatives that have advanced the field of statistics education. These documents, in chronological order, are the Quantitative Literacy Project (Scheaffer, 1986), The Principles and Standards of
School Mathematics (NCTM, 2000), and the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework (Franklin et al., 2007). Finally, the Conference Board of the Mathematical Sciences (CBMS) draft of The Mathematical Education of Teachers II (CBMS, 2012) will render recent perspectives in reform statistics education documents.

The Quantitative Literacy Project

The Quantitative Literacy Project, QLP, (Scheaffer, 1986) was a joint endeavor funded by the American Statistical Association and the National Council of Teachers of Mathematics in order to develop curriculum materials for statistics education. The curriculum materials, focusing on such topics as data exploration, probability, and inference, were meant to be teacher-friendly to an educational population largely foreign to statistical topics. Further, the QLP also offered guidelines for instruction:

1. Experiences (activities) for students should be focused on asking questions about something in the students environment and then finding quantitative ways to answer the question.
2. Problems should be approached in more than one way with an emphasis on discussion and evaluation of these different methods.
3. Real data should be used whenever possible in any statistics lesson, and classroom presentations should give students hands-on experience in working with data.
4. Traditional topics in statistics should not be taught until students have experienced and worked with simple counting and graphing techniques, and have established a foundation for those traditional ideas.
5. The emphasis in teaching statistics should be on good examples and building intuition, not on probability paradoxes or using statistics to deceive.
6. Student projects should be an integral part of any work in statistics.
7. The emphasis in all work with statistics should be on the analysis and the communication if this analysis, not on a single answer. (Scheaffer, 1991)
Within this framework of instructional pillars, one is capable of observing the authentic, meaningful contexts sought out by the author and supporters of the QLP. Also, the QLP was intended, by virtue of the infancy of the statistics reform movement and the intended enactment of a curriculum supplement, to serve as a model framework for inservice teacher education programs. Such an aim and vision, as McGatha, Cobb, and McClain (2002) contended over a decade later, never came to fruition.

The Principles and Standards for School Mathematics

Over a decade ago, the *Principles and Standards for School Mathematics, PSSM*, (NCTM, 2000) data analysis strand provided a sounding board for the initiatives of the QLP (Scheaffer, 1986) and carried on the work of its elder, the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). While textbook authors, curriculum developers, and many other stakeholders in the mathematics education arena began to observe the resonating tones and continued emergence of the data analysis strand in the mainstreamed, reform-based curricula, there were still large disparities in how statistics education topics were treated and enacted. The data analysis strand of the *PSSM* details that students in grades pre-K–12 should be able to:

- formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them;
- select and use appropriate statistical methods to analyze data;
- develop and evaluate inferences and predictions that are based on data;
- understand and apply basic concepts of probability. (NCTM, 2000, p. 175)

The *PSSM* strongly endorses the notion that students have to be active and increasingly sophisticated curriers of the data with which they interact. Students’ exposure to
meaningful and significant learning tasks in data analysis and probability “offers a natural way for students to connect mathematics with other school subjects and with experiences in their daily lives” (NCTM, 2000, p. 47). However, with the responsibility of developing learning environments and experiences that are undergirded with significant statistical capstones often delegated to the teacher, oftentimes with little support from mainstreamed curricula and little knowledge of the major differences that persist between statistics and mathematics, the enactment of the PSSM’s data analysis strand was challenging at the very least (Kader & Perry, 2006).

**The GAISE Report**

The Guidelines for Assessment and Instruction in Statistics Education (GAISE) (Franklin, et al., 2007) report was written under the auspices of the American Statistical Association in the spirit of advancing statistics education of students in the elementary, middle, and secondary levels (generally Levels A, B, and C, respectively) (Franklin & Mewborn, 2006). Specifically, the purpose of the GAISE report was to establish a developmental framework, building upon the NCTM’s PSSM (2000) data analysis and probability strand for teachers, administrators, researchers, teacher educators, and policy makers to use as a more specific and example-based treatment of the Data Analysis and Probability strand found in the PSSM (Peck, Kader, & Franklin, 2008). The GAISE document, while holding a multiplicity of purposes, particularly discusses and outlines what is meant to be a statistically literate high school graduate through a structural model of cumulative, hierarchical knowledge of statistics and data analysis topics. This
hierarchical model, manifested through Levels A, B, and C, indicates that students must progress through the content and conceptual understandings in Level A before they are capable and prepared to begin learning at Levels B and C. Franklin and colleagues assert that “Without such experiences, a middle school student who has no prior experience with statistics will need to begin with Level A concepts and activities before moving to Level B” (Franklin, et al., 2007, p. 13). For the purposes of this literature review, only Levels A and B will be detailed since the purpose of this study is strictly aligned towards elementary mathematics methods professors.

The GAISE Report indicates four underlying principles, including formulation of the question, data collection, data analysis, and the interpretation of results, of statistical investigation throughout Levels A, B, and C that culminates the holistic statistical education experience.

With respect to the four underlying principles of statistical problem solving, Level A includes the following action-based objectives:

1. Formulate the Question
   - Teachers help pose questions (Questions in contexts of interest to the student)
   - Students distinguish between statistical solution and fixed answer
2. Collect Data to Answer the Question
   - Students conduct a census of the Classroom
   - Students understand individual-to-individual variability
   - Students conduct simple experiments with non-random assignment of treatment
   - Students understand variability attributable to an experimental condition
3. Analyze the Data
   - Students compare individual to individual
   - Students compare individual to a group
   - Students understand the idea of a distribution
• Students describe a distribution
• Students observe association between two variables
• Students use tools for exploring distributions and association, including,
  – Bar Graph
  – Dotplot
  – Stem and Leaf Plot
  – Scatterplot
  – Tables (using counts)
  – Mean, Median, Mode, Range
  – Modal Category

4. Interpret Results
• Students infer to the classroom
• Students acknowledge results may be different in another class or group
• Students recognize the limitation of scope of inference to the classroom (Franklin, et al., 2007, pp. 23-24)

Franklin and colleagues (2007), along with Metz (2010) discuss several salient features that distinguish Level A, while also defining generalized objectives within the context of the four statistical principles referenced above. Below they are generally discussed:

• It is in Level A that children need to develop data sense -- an understanding that data are more than just numbers. Statistics changes numbers into information.

• Students should learn that data are generated with respect to particular contexts or situations and can be used to answer questions about the context or situation.

• Students should have opportunities to generate questions about a particular context (such as their classroom) and determine what data might be collected to answer these questions.

• Students should learn how to use basic statistical tools to analyze the data and make informal or casual inferences in answering the posed questions.
• Students should develop basic ideas of probability in order to support their later use of probability in drawing inferences at Levels B and C. (p. 23)

Level B builds upon the statistical knowledge structures established in Level A and establishes grounding for the statistics and data analysis experiences to come in Level C. Franklin and colleagues (2007) opine that Level B should continue to focus on the four major components, while giving students the opportunity to engage in authentic statistical activities. With respect to the four major components, students should:

1. Formulate Questions
   • Students begin to pose their own questions.
   • Students address questions involving a group larger than their classroom and begin to recognize the distinction among a population, a census, and a sample.

2. Collect Data
   • Students conduct censuses of two or more classrooms.
   • Students design and conduct non-random sample surveys and begin to use random selection.
   • Students design and conduct comparative experiments and begin to use random assignment.

3. Analyze Data
   • Students expand their understanding of a data distribution.
   • Students quantify variability within a group.
   • Students compare two or more distributions using graphical displays and using summary measures.
   • Students use more sophisticated tools for summarizing and comparing distributions including:
     – Histograms,
     – The IQR (Interquartile Range) and MAD (Mean Absolute Deviation),
     – Five-Number Summaries and Boxplots.
   • Students acknowledge sampling error.
   • Students quantify the strength of association between two variables, develop simple models for association between two numerical variables, and use expanded tools for exploring association including:
     – Contingency Tables for two categorical variables,
     – Time Series Plots,
     – The QCR (Quadrant Count Ratio) as a measure of strength of association,
– Simple lines for modeling association between two numerical variables.

4. Interpret Results
- Students describe differences between two or more groups with respect to center, spread, and shape.
- Students acknowledge that a sample may not be representative of a larger population.
- Students understand basic interpretations of measures of association.
- Students begin to distinguish between an observational study and a designed experiment.
- Students begin to distinguish between “association” and “cause and effect.”
- Students recognize sampling variability in summary measures such as the sample mean and the sample proportion. (pp. 35-36)

Just as in Level A, there are generalized learning outcomes in Level B. Franklin and colleagues (2007) describe several important benchmarks in students’ statistical knowledge and data handling maturation:

- Students become more aware of the statistical question distinction (a question with an answer based on data that vary versus a question with a deterministic answer).

- Students make decisions about what variables to measure and how to measure them in order to address the question posed.

- Students use and expand the graphical, tabular and numerical summaries introduced at Level A to investigate more sophisticated problems.

- Students develop a basic understanding of the role that probability plays in random selection when selecting a sample and in random assignment when conducting an experiment.

- Students investigate problems with more emphasis placed on possible associations among two or more variables and understand how a more sophisticated collection of graphical, tabular and numerical summaries is used to address these questions.

- Students recognize ways that statistics is used or misused in their world. (p. 37)
Table 1: *Levels of Student Understanding in GAISE Model*

<table>
<thead>
<tr>
<th>Process Component</th>
<th>Level A</th>
<th>Level B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulate Question</td>
<td>Beginning awareness of the statistics question distinction</td>
<td>Increased awareness of the statistics question distinction</td>
</tr>
<tr>
<td>Collect Data</td>
<td>Do not yet <em>design for differences</em></td>
<td>Awareness of <em>design for differences</em></td>
</tr>
<tr>
<td>Analyze Data</td>
<td><em>Use</em> particular properties of <em>distributions</em> in context of specific example</td>
<td>Learn to <em>use</em> particular properties of <em>distributions</em> as tools of analysis</td>
</tr>
<tr>
<td>Interpret Results</td>
<td><em>Do not look beyond the data</em></td>
<td><em>Acknowledge that looking beyond the data is feasible</em></td>
</tr>
</tbody>
</table>

The primary differences between Level A and Level B of the GAISE report are not primarily founded in the content itself, but rather the level of sophistication in which students are expected to interact with the content (as demonstrated by Table 1). As such, students who are working currently at Level B utilize the understandings that were fostered through their learning experiences at Level A. Examples of heightened content development would include the notions of students looking beyond the construction of a data display to considering notions of shape and outlying data values within the context of the problem, without making formal calculations. Franklin and Kader (2006) also speak to this transition of Levels through the use of representations that require proportional or multiplicative reasoning, through such data displays as pictographs, where one symbol is used to represent more than one response. Thus, as Franklin and colleagues (2007) have maintained throughout the descriptive space of defining Levels of
understanding, the maturational process of developing statistical thinking and reasoning skills deals with matters of both depth of cognizing and breadth of exposure.

**The Mathematical Education of Teachers II**

The Conference Board of the Mathematical Sciences (CBMS) consists of a consortium of mathematicians and statisticians who, like numerous other professional organizations, provide standards for professional practice. In 2001 the CBMS published *The Mathematical Education of Teachers* (2001b) as a document aimed at discussing the preparatory aims of preservice mathematics teachers. In early 2012 a preliminary second draft of this document was released, cleverly titled *The Mathematical Education of Teachers II*, reflecting the ebb and flow of the teacher training programs and instructional outcomes they should intention to produce.

One of the primary areas of emphasis of *The Mathematical Education of Teachers II* is a shift in statistical knowledge related to inferential, relational while also relating theoretical and empirical topics. This document states that probability and statistics instruction in grades 6 – 8 should:

- Develop an understanding of various ways to summarize and describe distributions.
- Develop an understanding of theoretical and empirical probability for both simple and compound events, and why they may differ for a particular empirical situation.
• Develop an understanding of statistical variability and its sources, and the role of randomness in statistical inference (CBMS, 2012).

Furthermore, the CBMS (2012) addresses the preparation of teachers with respect to statistics coursework. They advance that many of the traditionally regarded courses in statistics for mathematics, science, and engineering majors may not be particularly useful in gardening the ideas, and others, mentioned in the aforementioned bullets. The Board maintains that few mathematics and statistics departments actually offer class offerings that afford significant opportunities for K-12 mathematics teachers to grow in the mathematics and statistics content knowledge. Instead, “A modern version of this course, centered around statistical concepts and real-world case studies, and making use of technology in an active learning environment” would serve as fruitful in the development of profound statistical ideas (CBMS, 2012, p. 29).

Common Core State Standards

The Common Core State Standards (National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010) were established with the vision of creating coherence and direction in mathematics education learning outcomes on a large-scale effort. With large scale, high-stakes testing enveloping much of the mathematical reform movement thus far into the 21st century these standards seek to provide specificity and clarity to learning outcomes in mathematics instruction. As such, the Common Core State Standards seeks to provide a unified front of mathematical standards that are focused, thus thwarting against the once prevailing notion of
mathematical curriculum that is “a mile wide and an inch deep” in terms of significant concept development.

The Common Core State Standards were crafted in such a way that honors high level, meaningful mathematical knowledge structures. Thus, as students progress through grade levels, the depth at which content is developed in instruction increases to meet the need for robust levels of student understanding. Student understanding is measured not in terms of the perceived level of difficulty measured through an empirical coefficient, but rather, justification and reasoning is a hallmark whereby students are challenged to defend particular ways of thinking about mathematical ideas in novel situations. In terms of data analysis and probability, these standards indicate that probability and statistics curriculum should include interpretation of data, an informal treatment of inference, basic probability, and the use of probability to make decisions.

The Development of Statistical Thinking

Like many advances in mathematics and the natural science, the thinking processes that embody learning structures involve levels of active involvement in the learning experience (e.g. the interactive, multi-disciplinary approach to STEM education). As such, statistical thinking transcends the understanding of the arithmetical aspects of computations and calculations and embodies “the broad thinking skills that are invoked” throughout the spectrum of statistical inquiry (Pfannkuch & Wild, 1998, p. 459, emphasis by authors). Lane-Getaz (2006) upholds that some areas of statistical thinking
development can be fostered by thoughtfully engaging students throughout the investigative spectrum, which includes involving students in authentic research projects. As the GAISE document suggests, students at varying Levels of statistical knowledge formation will engage in this investigative process in increasingly more meaningful ways.

While a portion of this chapter has been committed to distinguishing, comparing, and contrasting mathematics and statistics, Moore (1997) acknowledged the need for a descriptive landscape to frame statistical thinking. To this end, Chance (2002) offers a progressive glimpse into statistical ways of thinking should involve students in active experiences that:

- Stress the totality of the investigative process
- Search for pragmatic answers to the question “Why?”
- Acknowledge the role of variation and how it should be interpreted
- Transcend the computational protocols highlighted in textbooks
- Establish new, more developed questions above and beyond the one(s) originally investigated

The work of Lesh and colleagues (2003) uphold that discrete learning activities in mathematics rarely yield learning outcomes with strong conceptual roots. Furthermore, projects are valuable assets in building statistical knowledge and provide a salient backdrop for exploring data (Garfield, 1993); however, it is stressed that adding an activity, collecting data for a day, or integrating a project into the scope of the curriculum is far from the pinnacle of fostering statistical thinking (Chance, 2002).
Statistical thinking envelopes not only the act of successfully producing data summaries and corresponding graphs to complete a project, but extends to the rich interpretation of the results and conclusions that are drawn from the data. It is often the case that students are quite capable of demonstrating competence of the former, with a disparaging amount of competency in the latter task of reading between and beyond the data (delMas, Garfield, & Chance, 1998). Consistent with the statistics reform movement, McClain and Cobb (2001) maintain that critical learning experiences taking place in investigative labs and activities must reach beyond the particulars of calculating and reporting to overarching ideas of variation, distributions, models, sampling, and inference. Thus, active, purposeful experience with data through projects and activities emphasize the broader investigative processes and assist students (1) to champion divergent types of thinking, (2) to question, and (3) to develop a skeptical outlook (Wild & Pfannkuch, 1999). These outcomes are component parts of sound statistical thinking.

In terms of curriculum integration, Franklin and Garfield (2006) uphold that the following five recommendations should be employed: (1) employ purposeful software and technology for enhancing statistics, (2) use real data, (3) engage students in multiple strategies of active learning, (4) emphasize big statistical ideas, and (5) employ multiple modalities of assessment to improve, evaluate, and extend the learning process. This relationship is shown in Figure 4. Further, learning tasks should be linked to a broader conceptual model (Lesh et al., 2003).
While it has been outlined and advanced that differences persist between statistics and mathematics (e.g. Cobb & Moore, 1997; delMas, 2004), the knowledge required for teaching statistics has not received significant treatment and appropriation in the literature (Watson, 2001). However, positions on the matter of knowledge required to teach statistics is slowly beginning to emerge (e.g. Groth, 2007). Burgess (2006) supplies a useful description, adapted from the work of Hill, Schilling, and Ball (2008) and influenced from the works of Shulman, which describe the content knowledge necessary to teach mathematics. The categories are:

- Common knowledge of content: ability to identify incorrect answers or inaccurate definitions, and the ability to successfully complete the students’ problems; and
- Specialized knowledge of content: ability to analyze mathematically whether a student’s unconventional answer or explanation is reasonable or
mathematically correct, or to give a mathematical explanation for why a process (such as a particular algorithm) works. (p. 5)

While these two categories, generally described as common knowledge of content and specialized knowledge of content, appear to offer a structural model in which to capture the knowledge necessary for teaching statistics, modifications are required between disciplines. Burgess (2006, 2008) levels the notion that the category of specialized knowledge of content is not particularly applicable to statistics education as defined by Hill and colleagues due largely to the notion that there are deterministic outcomes present within the implications of these categories. As discussed in detail in the previous section, the omnipresence of variability and the interpretive context of many tasks related to statistics and data analysis would suggest that a holistic lens for supporting divergent methods and conclusions may be a more suitable categorical description for such a framework.

The hypothesized framework proposed by Groth (2007) distinguishes and differentiates mathematical knowledge from statistical knowledge and reflects the knowledge structures proposed by Hill, Schilling, and Ball (2008) (Figure 5).
These underlying principles frame the statistical problem solving process and may be utilized as signals for the creation of a conceptualization of statistical knowledge for teaching (Groth, 2007). The four principles of statistical investigation are discussed through a case or example and described below, in terms of their mathematical and nonmathematical (statistical, interpretative) manifestations according to the four underlying principles of statistical problem solving advanced in the GAISE Report (Franklin et al., 2007).

**Principle 1: Formulate Questions**

Formulating statistical questions first requires that students possess the knowledge of the difference between a question that expects a singular outcome (i.e. what is the
height of the Sears Tower?) and one that foresees an answer that is based upon data that varies (i.e. how tall are buildings in Chicago?). The latter example suggests a statistical question in the sense that one would anticipate an answer that buildings in Chicago are of varying heights and could be reported in numerous ways, where the former portrays a non-statistical question of deterministic ends. In short, the “anticipation of variability is the basis for understanding” the difference between a question that is deterministic (or mathematical) in nature from one that is statistical in nature (Franklin & Garfield, 2006, p. 351).

Students and teachers can authentically formulate questions throughout the scope of the investigative process. Groth (2007) opines that asking and formulating questions about data in varying forms (e.g. box plots, scatter plots, etc.) require largely mathematical understandings since students have to derive questions from the knowledge they possess. Within a more specific and specialized application of this mathematical domain, it is also helpful to understand that students also experience difficulty reading different sorts of data displays, such as box plots due to the fact that data values are hidden (Zawojewski & Shaughnessy, 2000b).

A nonmathematical aspect of the question formulation phase rests largely in the notion that posing a statistical question anticipates answers based upon data that vary (Franklin & Garfield, 2006). This is starkly contrasted by the notion that mathematical questions in previous courses sought understanding through notions of proof-based demonstration of knowledge structures. Also, throughout the question formulation process, students often ask questions that are too broad and do not define measurable
variables. Thus, it is imperative for teachers to possess a strong knowledge of the statistical productiveness of questions to guide students to posing relevant, measurable questions for investigation (Groth, 2007).

Principle 2: Collecting Data

Franklin and Garfield hold that the most salient aspects of collecting data is the notion that students must be able to first acknowledge variability and then must account for such variability in designing studies in purposeful ways to reduce differences. In terms of knowledge domains, Groth (2007) maintains that collecting data for the purpose of analysis requires common knowledge that is largely mathematical.

Two mathematical manifestations of collecting data are grounded in the ideas of measuring quantities and constructing simulation algorithms. In the first case, statistical studies are oftentimes built upon the notion of measuring some sort of data (e.g. the heights of participants). As such, students have to possess a strong sense of measurement in order to properly analyze the data. The second aspect that Groth (2007) outlines from a mathematical heritage in the data collection process involves the process of analyzing a corpus of data that is generated through a model or algorithm in order to come to a better understanding of a phenomenon (e.g. the discrete probability of getting a 7 when two dice are rolled and their faces summed). In this way, a student’s mathematical knowledge is tasked to develop a simulation protocol that accurately captures and maintains the authentic circumstances enveloped by the context of the problem under question.
Nonmathematical knowledge is also crucial for the data collection process. Included in such a knowledge corpus would include developing questions for surveys, determining the type of study to employ given the particular question, and establishing ways in which to control for variation within the process of collecting data. Furthermore, a study conducted by Derry, Levin, Osana, Jones, and Peterson (2000) has shown that the data collection process is further complicated by students’ difficulty determining whether to implement random sampling protocols or to utilize a random assignment model. Groth (2007) maintains that this difficulty may be largely due to the notion that many inferential statistics classes do not offer much treatment to such salient ideas in the data collection process of statistics, suggesting that many teachers have not had proper exposure to these ideas even if they did have an elementary or mathematical statistics class.

**Principle 3: Analyzing Data**

The most fundamental purpose of a statistical analysis is to provide a framework that indicates the variability of the data (Franklin & Garfield, 2006). When SAT I Math scores are described as normally distributed with mean 518 and standard deviation 114 (College Board, 2004), the focus is grounded in how the scores differ from the mean. Reference to the normal distribution describes a bell-shaped dispersion of scores and the standard deviation indicates the level of variation from the mean. Similar discussion can also be rendered for other variation-based statistical notions such as the margin of error and confidence levels. Defining and accounting for variation is the primary purpose of the data analysis phase of the statistical investigative process.
Mathematical knowledge related to the data analysis component of the statistical problem solving process lies in computing descriptive statistics such as the mean or median (Groth, 2007). Despite these seemingly straightforward descriptions, research has shown that teachers and “experts” (Groth & Bergner, 2006; MacCullough, 2007) have demonstrated that within these topics lie conceptual impasses and incorrect mathematical understandings of the algorithms used to compute such statistics. To this end, Mokros and Russell (1995) found that students also struggle with the mathematical and interpretative constructs of the arithmetic mean and oftentimes perceive it as simply a procedure or algorithm.

While some of the impetus for analyzing data has a home in the mathematical realm, it has been argued that a more significant area of occupation belongs to the nonmathematical, interpretative domain (Groth, 2007). While the process of calculating the arithmetic mean is a frank mathematical task, the knowledge required to assess the worth of utilizing such a statistic occurs in an interpretative context. For example, students were to be asked to consider the following situation:

A small object was weighed on the same scale separately by nine students in a science class. The weights (in grams) recorded by each student were 6.2, 6.0, 6.0, 15.3, 6.1, 6.3, 6.2, 6.15, 6.2. What would you give as the best estimate of the actual weight of this object? (Konold & Pollatsek, 2002, p. 268)

In a problem such as this, the authors maintain that students should perceive each data point or observation as specific, but unidentified value, of the same object (e.g. the weights (in grams) of a small object). As such, the deviations in weights are reconciled as random measurement errors or “signals in a noisy process”, where the signal is the typical value and the noise is the surrounding errors in measurement. An interpretive,
nonmathematical lens is required to analyze such a problem context, where the method of determining the best estimate of the weight of the small object is unclear. Students are confronted with the difficult task of determining how to parse out the noise in the problem. Students consider numerous approaches: “Should I compute the arithmetic mean?”, “Should I report the mode?”, “Should I find the median?”, “Should I remove the outlying value and report the adjusted mean?”, along with other conceptions. In fact, Groth (2005) found that students are not judicious in their thought processes related to tasks that involve point estimates or typical values, many of whom use the arithmetic mean without considering the context or “noise” surrounding the task. Instead, as Wild and Pfannkuch (1999, p. 228) stated, students should have experience of problems that “propel [them] back to the context sphere to answer the questions, ‘Why is this happening?’ and ‘What does this mean?’”

**Principle 4: Interpreting Results**

Interpreting the results of a statistical event is made within the existence of variability. Even at very robust levels of significance and data collection protocols, samples vary because of the very nature of variability, accountable to individual differences (e.g. elements within the sample will rarely possess the exact same characteristics) and sampling methods (e.g. randomized, block, stratified, etc. designs). For example, results from a poll of students who took the SAT must be considered as strictly an estimate that can vary from sample to sample. The act of generalizing the poll results to the entire population of students who took the SAT must allow for the
possibility that results among different samples can (and will) vary. In this particular
case, such variation could be attributable to innumerable factors including the students’
high school, intelligence, coursework, socioeconomic status, and the like.

Mathematical competencies abound in the act of interpreting the results of a statistical task. In some cases, students may construct a confidence interval by finding the margin of error at a particular confidence level to assert a range of limits, as opposed to a single point estimate, to capture data from a sample. Perhaps the most salient aspect related to the interpretation of hypothesis testing results is the concept and calculation of the \( p \)-value. The \( p \)-value is defined as the probability of getting a test statistic that is at least as extreme as the one that was observed, given that the null hypothesis is true (i.e. the probability of a Type I error). Groth (2007) upholds that teachers must be well adept for countering and redirecting students misconceptions related to the \( p \)-value, which largely resides in a common misunderstanding that the \( p \)-value “gives the probability that the null hypothesis is true or the probability that it is false” (p. 433).

There are also nonmathematical aspects of interpreting results from a statistical task. Considering the case of \( p \)-value, one is faced with the task of interpreting the level of statistical significance utilized in a hypothesis test based upon the context of the problem. For example, students should be able to distinguish cases where robust significance levels, such as \( \alpha = 0.005 \), may be utilized in high-risk pharmaceutical or medical research, whereas less profound levels of significance, such as \( \alpha = 0.100 \), may be better suited for research questions with a heritage in the social sciences. Furthermore, even after a suitable significance level has been determined based upon the context of the
problem, the interpretation process does not end with typical conclusions starting with statements such as “There is not sufficient sample evidence to conclude that…” which imply the analysis has concluded as quickly as it began (Rossman, Chance, & Medina, 2006). Rather, students and teachers alike should be engaged in a highly interpretive, nonmathematical survey of the contextual landscape of the problem, searching for notions of both conclusiveness and convolution amidst the omnipresence of variability.

Summary

The first portion of this chapter discussed the seminal works of Lee S. Schulman (1986; 1987a; 1987b). Schulman’s popularized notion of pedagogical content knowledge serves as a framework to capture the notion that particular skills and dispositions are necessary to effectively deliver meaningful instruction within an educative setting. Additionally, Schulman advanced the praxis of teaching practice with content knowledge in order to maximize learning outcomes.

The chapter then advanced into the work of Deborah Ball and colleagues, who extended Schulman’s notion of pedagogical content knowledge into a schematic map of the mathematics knowledge for teaching (e.g. Ball 2000; Ball, 2002; Ball, Hill, & Bass, 2005). Particularly, this research stressed the importance of understanding the understandings and misunderstandings of teachers and students alike related to content-specific notions. To this end Ball stresses that thinking and conceptualizing processes should rest at the foreground of studies in mathematics education.
Next, a necessary comparison of mathematics and statistics took place. It was during this period in the chapter that tribute was paid to the theoretical groundings that mathematics offers to statistics. Yet, a clear distinction was made between the deductive heritage of mathematics and the methodologically inductive nature of statistics. In this portion of the chapter the role of context was also delineated and discussed as it relates to mathematics and statistics, whereby the former seeks to remove context for the sake of generalization and the latter ascertains rich meaning from it (Moore, 1997).

Foundational documents, globally referred to as standards, framed the reform of statistical content and instructional outcomes during the course of the last twenty-five (25) years. The Quantitative Literacy Project (Scheaffer, 1986) was the first document of this sort that offered an effort to develop curriculum materials in statistics education. The QLP offered broad guidelines for instruction and served as a starting point in the discussion of reforming statistics instruction by emphasizing understandings instead of computational exercises and procedures. The Principles and Standards for School Mathematics, PSSM, (NCTM, 2000) data analysis strand endorsed the notion that students must be active and increasingly sophisticated curriers of the data with which they interact. The PSSM stressed that students need to be exposed to meaningful and significant learning tasks related to concepts in data analysis and statistics. Finally and most recently, the Guidelines for Assessment and Instruction in Statistics Education (GAISE) (Franklin, et al., 2007) was written under the auspices of the American Statistical Association in the spirit of advancing statistics education of students in the elementary, middle, and secondary levels (generally Levels A, B, and C, respectively)
through a developmental framework of increasingly more refined understandings. The GAISE document particularly discusses and outlines what is meant to be a statistically-literate student through a structural model of cumulative, hierarchical knowledge of statistics and data analysis topics by providing a piece-wise perspective of concept development through Levels A, B, and C.

Furthermore, the development of statistical thinking was established through a learner-centered approach. Statistical thinking transcends the understanding of the arithmetical aspects of computations and calculations and embodies a movement towards rich, authentic understanding of statistical and data analysis phenomena and away from procedural counterparts. Congruent with a movement towards understanding, it is also advanced that students are taught through multiple instructional modalities and assessment techniques embrace the idea of improving and extending instruction.

Finally, this chapter ends with a discussion on the knowledge for the teaching of statistics. Particularly, treatment is extended to common knowledge of content and specialized knowledge of content, through the four underlying principles of statistical problem solving advanced in the GAISE report, including formulating questions, collecting data, analyzing data, and interpreting results. Within these principles, specific treatment is rendered to the deterministic, mathematical outcomes with those that are statistical in nature.
CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to describe the experiences and perceptions that professors of K-8 mathematics methods courses hold related to statistics. This project details the descriptive, interpretive qualitative research design and the methodology utilized to investigate these professors’ experiences and perceptions related to statistics in K-8 mathematics teaching methods courses. This chapter commences with a statement grounding the theoretical framework of the study, followed by a concise description of the study, and complemented by the descriptions of the sample. The data collection sections detail the sources of data as well as data management and data organization for analysis. After a description of the process for data analysis, the chapter concludes with a discussion of the limitations and trustworthiness of this research methodology.

Theoretical Framework

Constructivism is the theoretical framework that has been utilized within the scope of question posing, data collection, and analysis of this dissertation study. Paul (2005) upholds the imperative nature of grounding a research study through a theoretical
framework so that the questions and analysis of the research is transparent to the reader. Constructivism is an interpretative stance which regards human beings as active meaning-makers within their realities. Such meaning making frames are acquired through physical and temporal data, acquired through senses, beliefs, prejudices, opinions, attitudes, and other mental processes that are obtained through both individuals and groups (Guba & Lincoln, 2004). To this end, the meaning-making process is informed through actual events and concrete situations that embody the lived experiences of individuals. Specifically, this research is centered specifically on the totality of the constructs or the amalgam of sense- and meaning-making structures of the participants in this study.

While the positivist tradition has typically focused on the physical realities of individuals, constructivism-based research champions the enacted reality of experience, drawing upon the meaning- and sense-making activities that ascribe meaningfulness to the participant. As Lincoln (2005, p. 61) opines, “constructivists aim to counterbalance the strong behaviorist and measurability foci of experimental social science with a re-emphasis on the immeasurable forms of meaning, and…deep understanding of the meaning-making processes” that contribute an unadulterated sense of meaningfulness according to one’s own experience. Constructivist theory draws upon the notion that conventional scientific approaches to research have fallen short in explaining the experiences, and manifestations of such experiences, of individuals within and amidst the impetuses that define their knowledge and understandings.
As such, constructivist theory contends that understanding reality for individuals is much less concerned about objective and physical truth, fallible through the lens of the enactment of daily life events and, in the case of this research, the experiences and teaching practices around a particular segment of the school mathematics curriculum, statistics. Thus, the focus and the analysis of the research within this study will not seek to objectivity, predict, or control data through methods of positivistic means; rather, the researcher, through a phenomenological analysis grounded in constructivism, will draw upon the multiple realities and pluralistic perspectives that are presented by the professors that participated in the study. It was the aim of the researcher to accurately depict the fullness and complexity of the data through the realities of those who have experienced the phenomenon of teaching K-8 mathematics methods courses to preservice teachers by honoring the human meaning-making perspectives at work within their roles as professors.

**A Call for Research**

Preservice teacher candidates in K-8 mathematics methods courses should be exposed to strategies and content aligned with *PSSM* (NCTM, 2000), state mathematics standards (e.g. Ohio Department of Education, (2001)), and standards of accreditation (i.e. the National Council for the Accreditation of Teacher Education [NCATE], 2007). Within the constructs of this belief lies the notion that teachers should be guiding their students through standard-based instruction that is aligned with pedagogical-sound
methods (Stein, Smith, Henningsen, & Silver, 2000). And while pre-K–12 teachers have been studied regarding aspects of their statistical knowledge (Peters, 2009), there is no line of work that has specifically addressed K-8 mathematics methods professors’ experiences with and perceptions of statistical topics. Instructors and professors in colleges and departments of education and/or mathematics who teach prospective K-8 teacher candidates in mathematics methods and courses have not been investigated to this point in the literature regarding their experiences and perceptions of statistics through their role as professor.

A mathematics methods course for K-8 teacher candidates holds a significant role in the development of salient outcomes and understandings related to curriculum and instruction. In short, these courses are responsible for providing an ethos for not only what is taught and valued in K-8 mathematics instruction, but also a platform of how this instruction should take place and what it looks like in practice. It follows that the practices that ensure in a K-8 mathematics methods course for preservice teachers stands to have a high degree of influence on the future teaching practices of preservice teachers (Ensor, 2001).

The milieu of the K-8 mathematics classroom is surrounded with standards, best teaching practices, and high stakes testing. Teachers are expected, perhaps now more than ever, to be increasingly self-aware of curriculum, instruction, and assessment, while ultimately increasing student achievement (Hill, Rowan, & Ball, 2005). With the proper respect and honor given to the profound influence (positive, neutral, or negative) of K-8
mathematics teaching methods courses, it is fundamentally imperative to understand the perceptions and experiences of those who instruct these courses.

Furthermore, institutional differences account for another variable that is unique to mathematics and science methods courses for preservice teachers (J. Werner, personal communication, April 1, 2010). According to Werner, some mathematics methods courses for elementary school preservice teachers are taught in colleges and departments of education by education faculty, while others are taught in departments of mathematics by mathematicians and mathematics instructors. Additionally, Werner notes that K-8 mathematics methods courses for preservice teachers may be taught by graduate students, curriculum generalists (those who do not have a content specialization), mathematics educators, mathematicians, or statisticians. These differences, while seemingly insignificant, may reveal differences in the way that professors of K-8 mathematics methods courses have experienced and perceive statistics within their role as instructor.

Tarr, et al. (2008) found that content related to data analysis and probability has been underrepresented in the enacted school mathematics curricula. Further, Cooney (1999) reports data to support the notion that preservice teachers are deficient in their understandings of topics traditionally taught in school mathematics, despite the fact that many realized much success in studying high-level mathematics at the undergraduate level. Hill, Rowan, and Ball (2005) expands upon Cooney’s work and state that “teacher preparation and job experience are poor proxies for the kinds of teacher knowledge and skill that in fact matter most in helping students learn academic content” (pp. 374-375).
Very little investigative work has taken place within the domain of preservice mathematics teacher educators to this point in the literature. Rather, investing how K-8 mathematics methods professors discuss their experiences and perceptions related to statistics will provide a glimpse into the ways of representing and knowing of a small, yet purposeful, sample. Furthermore, understanding the foundational notions of experience and perception of statistics by K-8 mathematics methods professors undergirds the advancement of statistics education and preservice teacher preparation, both at the university and K–8 levels.

By investigating the ways in which foundational ideas, such as the arithmetic mean, are explained and understood by instructors and professors of K-8 mathematics methods courses, the literature base will be extended and a new field of research may expand, namely that of researching the ways in which K-8 mathematics teacher educators discuss their experiences and perceptions related to statistics, and how such knowledge and dispositions may be subsequently manifested in preservice teachers’ knowledge. With this established, it is important to state the overarching goal of this study was to better understand the experiences and perceptions of statistics of a small group of K-8 mathematics methods professors. Further, this study, along with others in the future, may better inform curriculum modification, professional development, and enrichment for preservice teachers, inservice teachers, and mathematics and statistics educators, while ultimately opening dialogue for best practices among mathematics and statistics educators in courses related to preservice and inservice teacher education.
Description of the Study

The descriptive and interpretative components pertaining to a qualitative research study align extremely well for framing how professors of K-8 mathematics methods courses discuss their experience related to and perception of statistics in their roles as preservice teacher educators. Opposing positivistic methods for research questions rich in authentic data, van Kaam (1966) opined that predetermined experimental designs and statistical methods “‘may distort rather than disclose a given behavior through an imposition of restricted theoretical constructs on the full meaning and richness of human behavior’” (p. 14, as cited in Moustakas, 1994, p. 12). Because educational institutions are based upon human interactions and subjective epistemological frameworks and perspectives, Patton (2001) suggests that qualitative methods serve to better embody lived experiences.

In the process of framing a study, Patton (2001) outlines five points which serve as beacons to indicate the presence of a qualitative research project.

1. The intent of the research seeks to address a process, implementation, or development of a program or its participants.
2. Individualized outcomes are central to the explanation.
3. Rich details, rooted in the accounts of participants, are required to provide insight and analysis.
4. The distinctiveness and multiplicity of individual accounts is central to the research question.
5. The research question seeks to understand and participant accounts are central to this understanding.

To this end, qualitative research methods were particularly helpful for unearthing the instructional experiences and understandings of the experiences and perceptions of K-8 mathematics methods professors related to statistics.

The overarching goal of this preservice teacher educator centered research project was to render a vivid picture of the experiences and perceptions of K-8 mathematics methods professors related to statistics. In particular, it was the goal of the research study to capture the “’essences’” of these professors’ experiences and perceptions (Sanders, 1982, p. 354).

It was determined by the researcher that participants from the research study would be limited to those K-8 mathematics methods professors in a northeastern state of the United States who teach at a university in the state system of higher education. By limiting participants to one particular state and type of institution, state standards and credentialing of teacher education programs would remain structurally fixed in terms of the level of teacher certification and the types of degrees offered at the K-8 level.

First, the researcher utilized information provided by an executive board member on this state’s Council of Teachers of Mathematics. Seeking information through a “gatekeeper” for purposes of gaining entry is encouraged in qualitative research (Bailey, 1996; Holloway, 1997). This individual was very well-informed of those who teach or have taught K-8 mathematics methods courses in this particular state, while also being positioned to provide assorted initial demographic information of potential participants.
from her myriad interactions with state system mathematics educators. Then the researcher contacted the deans’ offices at the respective state system institutions in order to confirm the individual or individuals who taught (or who had taught within the last two academic years) K-8 mathematics methods courses (or the equivalent) at their institution, followed by securing the professors’ email addresses and/or phone numbers. After this data was collected, potential participants were informed of the nature of the study via email, and were asked to if they were willing to participate in a study related to mathematics education. Those individuals who were willing to participate in the study were then mailed a demographic survey (Appendix B) and were asked to complete and return it prior to the interview. After confirming consent to participate a mutually agreeable date, time, and location were established and, the K-8 mathematics methods professors were then engaged in a semi-structured interview about instructional experiences and perceptions of statistics within the context of their K-8 mathematics methods course.

The findings that emerged from the analysis and interpretation of professor interviews yielded interpretive summaries for each individual participant and offered composite findings for the participants in aggregate.

Framework for Phenomenology

Since the literature and research base of the experiences and perceptions of K-8 mathematics methods professors related to statistics is sparse, the methodological
utilization of phenomenology is favorable (Creswell, 2007). The methods utilized in this study, informed by phenomenology, are intended to articulate the perceptions and experiences related to statistics of professors of K-8 mathematics methods as a description of the essence of their experience (Creswell, 2007; Giorgi, 1994; Moustakas, 1994, Sanders, 1982).

Perceptions, through lived experiences, constitute the principle source of knowledge in phenomenological studies, thus affixing textural descriptions relating what was experienced and structural descriptions relating how it was experienced (Creswell, 2007, p. 227). Sanders (1982) opines that “Phenomenology seeks to make explicit the implicit structure and meaning of human experiences” (p. 354). The robustness of phenomenology is situated, primarily, in the emergence of descriptive data of a phenomenon that is meaningful to the research participants (Atkinson, 1972, as cited in Sanders, 1982). Thus, the subjective understanding of an experience, rather than the objective observation is championed. Further, the interpretive derivation of categories and their linkages produce insights about new understandings about a particular phenomenon, such as the experiences and perception of statistics, from the eyes of K-8 mathematics methods professors.

Furthermore, a phenomenological design permits the mining, interpretation, and expression of these professors’ experiences and perceptions, which will provide significant insight into this rather uninhabited area of study. Additionally, it may inform the future instructional practices, curricular decisions, and professional development of professors who teach K-8 mathematics methods courses, while providing a potential
gateway for further research in the areas of preservice and inservice teacher preparation in general and specifically the statistics education experiences of preservice teachers at the postsecondary level.

**Methods for Phenomenological Analysis**

Giorgi (1985, as cited by Moustakas, 1994) outlined two descriptive levels of the phenomenological approach. The first level consists of the original data, containing raw descriptions through open-ended questions and dialogue. The second level consists of the researcher’s descriptions of the structures from the participant’s experience through reflective analysis and interpretation. To this end, Giorgi (1985, p. 151) upheld that “by adopting a strictly descriptive approach, we can let phenomena speak for themselves…” (as cited by Moustakas, 1994, p. 13). Through this approach, the descriptive characteristics of those professors who instruct K-8 mathematics methods classes will be captured within the frameworks of their experiences and perceptions of statistics.

As previously indicated, the primary vision for phenomenological research is to capture the essence of the experience as it was for the persons who have lived it. Individual descriptions captured in the descriptions of the participants are then synthesized to essential or general descriptions about the phenomena (Davis, 1991; De Castro, 2003). Accordingly, Giorgi (1979) articulated a pragmatic framework for the analysis of data using a phenomenological approach:
(1) The researcher reads the entire description of the learning situation straight through to get a sense of the whole. (2) Next, the researcher reads the same description more slowly and delineates each time that a transition in meaning is perceived with respect to the intention of discovering the meaning…from a series of meaning units or constituents. (3) The researcher then eliminates redundancies and clarifies or elaborates to himself the meaning of the units he just constituted by relating them to each other and to the sense of the whole. (4) The researcher reflects on the given units, still expressed essentially in the concrete language of the subject, and comes up with the essence of that situation for the subject. Each unit is systematically interrogated for what it reveals. The researcher transforms each unit, when relevant, into the language of psychological science. (5) The researcher synthesizes and integrates the insights achieved into a consistent description of the structure of learning. (p. 83, as cited by Moustakas, 1994, pp. 13-14)

In this particular dissertation study, the researcher utilized the methods cited by Giorgi (1979) in order to traverse the interview transcriptions and highlight substantial statements that provide an indication as to how the professors experience and perceive statistics in their role as preservice teacher educators. From these significant statements, the researcher created “clusters of meaning” through which significant statements were manifested into themes or key points (Creswell, 2007, p. 61). Then, as Creswell discusses, the researcher prepared a textural description of what the professors experienced that influences their perceptions of statistics, while also preparing a
structural description of *how* these professors understood their experiences related to statistics within the context of teaching preservice K-8 (mathematics) education majors.

**Sampling Methods**

Sanders (1982) asserted that the uniqueness of each research topic may render divergent methods necessary to capture phenomenological themes. Thus, participant data emerged through semi-structured interviews, obtained from a sample of three (3) professors of K-8 mathematics methods. These professors each teach in the same state system of higher education in a northeastern state in the United States. By limiting participants to one particular state and type of institution, state standards and credentialing of teacher education programs would remain structurally fixed in terms of the level of teacher certification and the types of degrees offered at the K-8 level.

**Research Questions**

Patton (2001) poses the emblematic question of phenomenology as, “What is the meaning, structure, and essence of the lived experience of this phenomenon for this person or group of people?” (p. 104). This study has investigated the experiences and perceptions, related to statistics, of those professors who teach K-8 mathematics methods courses for preservice teachers. This investigation will seek to answer the following research questions:
1. What are the experiences of preservice K-8 mathematics teacher educators related to statistics?

2. What are the perceptions of preservice K-8 mathematics teacher educators related to the statistics?

**Sample Selection**

The sample selection is discussed in terms of an overview of the methodology utilized and the participant selection.

**Overview**

A purposive (or judgment, Marshall, 1996) sampling of three (3) professors that currently teach, or have taught within the last two years, K-8 mathematics methods courses illustrates stratified purposeful sampling (Patton, 2001). According to Polkinghorne (1989; as cited in Creswell, 2007) and Sanders (1982), a sample of three (3) participants falls within the acceptable sampling parameters of a phenomenological study. The purposeful variability among the selected professors and the institutions where they teach strongly represents the demographical information from institutions of higher education in the western part of this northeastern state, which provides cadence to the significance of patterns or themes found across the participants. Marshall (1996) indicates that sampling a range of subjects may be particularly useful for the analysis of a study, where demographical differences may play a factor in such perceptions and experiences related to statistics.
Participant Selection

Selecting professors who taught K-8 mathematics methods courses from various institutions across a state system of higher education allows for more breadth and depth of the phenomenological experiences and perceptions related to statistics (Marshall, 1996). While demographic variability among institutions is an advantageous characteristic, the sample of individuals was selected to reflect homogeneity with respect to their roles as K-8 mathematics methods professors in one northeastern state in the United States from universities in the state system of higher education (Sanders, 1982). A homogeneous sample in which all research participants share a similar familiarity of teacher preparation programs and the respective state academic standards corresponds well to Creswell’s designation of phenomenology, stating that it describes the “meaning for several individuals of their lived experiences of a concept or a phenomenon” (2007, p. 57).

The criterion for participant solicitation was slated such that only one elementary school mathematics methods professor from an institution would participate in the study. Participant selection at institutions where there was more than one instructor of the K-8 mathematics methods course who was willing to participate in the research study was selected based upon the frequency in which they teach methods class, with preference given to the individual who taught the course more often. Additional considerations for the purposeful selection of participants included the academic department where the K-8 mathematics methods course was offered (e.g. mathematics or education), professor’s experience, and professor’s academic background were taken into account in order to
provide the greatest breath and variation of candidates. Following review of the data collected from the “gatekeeper” and deans’ offices, the sample participants were contacted to verify their status as K-8 mathematics methods instructors; once again verify their willingness to participate in the research study; issue the demographic survey; and establish a meeting time, date, and location for the interview. Since the methods utilized for the selection of participants did not control for the individual perceptions and experiences related to statistics of professors who instruct K-8 mathematics methods courses, variability among participants will likely span along a continuum undefined in the literature.

**Data Collection**

The data collection process in a phenomenological research study is structured by the notion of setting biases aside throughout the collection and interpretation process. Moustakas (1994) described the process of data collection by persisting:

The researcher following a transcendental phenomenological approach engages in disciplined and systematic efforts to set aside pre judgments regarding the phenomenon being investigated in order to launch the study as far as possible free of preconceptions, beliefs, and knowledge of the phenomenon from prior experiences and professional studies – to be completely open, receptive, and naïve in listening to and hearing research participants describe their experience of the phenomena being investigated. (p. 22)
Each of the three (3) purposefully selected K-8 mathematics methods professors agreed to participate in the study when contacted via email to determine their willingness. As each individual granted approval, a letter and the recruitment email (Appendix D) was sent detailing the study and the confidentiality procedures. Following approval, each participant also received a demographic survey form (Appendix B) to obtain personal information and particular details about his or her background information. After the participants completed the demographic survey and consented to an interview, it was determined that they acknowledged the purposes of the study and that participation would not bring about physical, personal, and legal harm and nominal social or psychological risk.

Following the demographic survey, a 90-minute, in-depth, semi-structured interview was scheduled, recorded, and transcribed (Sanders, 1982). The interview protocol can be found in Appendix C and the informed consent and audio/video consent form can be located in Appendix A. According to Sanders, the semi-structured interview is one of three effective methods for data collection in a phenomenological study. The interview structure utilizes open-ended questions that are informal and engaging for the participant, while making them feel relaxed and at ease. Moustakas (1994) asserted that “The interviewer is responsible for creating a climate in which the research participant will feel comfortable and will respond honestly and comprehensively” (p. 114). The effectiveness of the semi-structured interview format has been demonstrated through previous studies (e.g. Pasquerilla, 2008).
Recording the interviews allowed the researcher to commit his full attention to the participant, while not over generalizing or misinterpreting the data (Sanders, 1982). Also, the recording process affords the opportunity to transcribe the interview, while appropriating the occasions to mine and sift the data various times (and through various mediums) in hope of discovering new meanings, interpretations, and themes based upon the responses of the participants. During the interview process, notes were also taken according to the responses of the participants to ensure meaningful and appropriate follow-up questions for purposes of expansion and clarification (Rubin & Rubin, 2005).

Creswell (2007) endorses the practice of involving participants in the audit process to ensure the accuracy and intentions of their responses. Therefore, following the interview, each participant received an electronic copy of the transcribed interview and reviewed it for precision and clearness, provided that they were willing to do so. A concluding telephone interview summated the interview to discuss the transcription, as needed.

Organizing the data collected and gathered from the interview process is extremely important throughout the interpretation and analysis segments of the study (S. Iverson, personal communication, July 2008). The data collected was organized by keeping the audiotapes from the interviews in a box, filing the transcribed interviews in manila file folders according to the participant, keeping field notes in a journal specific for each participant, and maintaining a researcher’s journal contained within one spiral bound notebook. Further, electronic documents were organized within a desktop icon
with folders specific to both the research participants and segments of data collection and analysis.

**Trustworthiness**

Numerous strategies support the trustworthiness of this study. These strategies include: adherence to the methods and procedures, variation in the sampling techniques to provide a rich demographic base for data collection, thorough descriptions of the participants, contexts, and findings to identify the transparency of this study to other situations, the position of the researcher or situating of self, an audit trail, and triangulation of the data (Mertens, 2005). Finally, the protection of those individuals who were research participants was achieved through informed consent and measures to ensure confidentiality.

Throughout the extent of this study, the researcher’s position within the phenomenological research model as a participant in the semi-structured interview and interpreter could possibly evoke bias which could greatly limit the trustworthiness of the interpreted findings. Moustakas (1994) called for the practice of bracketing preconceptions that could possibly serve as a detriment to the interpretation of the data. Bracketing involves the exposure of self-reflections that are critical in nature by asserting the researcher’s preconceptions as a body of assumptions. Further, bracketing serves as a distinct beacon for continual self-reflection based upon the defined underpinnings of the researcher’s assumptions, while ensuring that he is situated in a perspective that allows
him to perceive his participants’ experiences through their interactions with the phenomenon. Appendix E includes the bracketing of the researcher’s assumptions, which are further supported by the researcher’s theoretical framework provided earlier in the chapter.

Moreover, numerous strategies support the trustworthiness of this study. These are captured in the researcher’s commitment to rigorous research techniques and his awareness in creating an audit trail of documents and notes that capture his decision making processes. Furthermore, the process of verifying the researcher’s interpretations, both through self-reflection and triangulation of data sources promoted soundness throughout the data analysis segment of the research project.

Denzin and Lincoln (2000) are very clear to assert that triangulation is not an empirical technique to validate the data that is collected in research, but rather, it is a method for ensuring and enhancing trustworthiness through a comprehensive examination of the phenomena. The triangulation technique utilized in this research study is asserted by Denzin (1978) and Denzin and Lincoln (2003) as investigator triangulation. In this method, multiple researchers are invested in the research and data analysis process. In this study another mathematics educator, Richard Busi, a doctoral student in mathematics education at the University of Florida, served as the investigator through which the analytic process was triangulated. This coupling with Mr. Busi permitted multiple perspectives of data analysis, both from the researcher and the lens of another mathematics educator, promoting a more complete, consistent, and richer framework for analysis (Mauthner & Doucet, 2003).
In particular, the researcher sent Mr. Busi a copy of the transcribed interviews via email, along with an electronic copy of the interview protocol (Appendix C). For a period of several weeks, the researcher and Mr. Busi spent time reviewing the transcripts and making notes of the personal meanings he made of the participants’ responses. While the researcher developed Key Points around each of the questions posed to the participants, Mr. Busi made general notes related to overarching ideas or themes. The researcher and Mr. Busi then held an extensive meeting to discuss their findings. Question by question, the interview questions were read, along with a summary of each participant’s response. Then, the researcher discussed with Mr. Busi his perspectives related to the interpretation of the response, along with the Key Points that he established. While there were not points of forthright disagreement, Mr. Busi did provide numerous inputs and perspectives, which promoted a deeper investigation on the part of the researcher. For example, while the researcher initially held that P-1 was pushing for a reform-based perspective of statistics in the K-8 curriculum, Mr. Busi advanced the notion that the core of P-1’s explanation was founded upon the notion of preparing preservice teachers to interpret and convey high stakes test score data to future stakeholders. Thus, the process of investigator triangulation proved to be both effective and enriching to the extending the corpus of data. Mr. Busi’s reflexive statement related to statistics education is found in Appendix F.

The following chapters will contain the findings from the study and end with a discussion of the findings, as well as limitations of the study and implications for future research.
CHAPTER IV
RESULTS

Research participants were interviewed with the intention of gaining information according to one overarching research question: What are the experiences and perceptions of kindergarten to eighth grade (K-8) mathematics teacher educators’ related to statistics in their mathematics methods courses? Data analysis revealed Key Points (i.e. essences) that are organized in order of the questions presented to the participants. The questions that were asked of the participants can be found in Appendix C, and were developed in order to capture the participants’ perceptions and experiences related to statistics. As the Key Points are presented, a textural description of these experiences follow, which include supporting data collected from the interviews. Commentary also provides transition and depth to the supporting Key Points. At the end of Chapter IV, brief summaries will provide a generalized rendering of the perceptions and experiences of each individual participant.

Interviewees are differentiated by the symbols “P-1” (i.e. participant 1), through “P-3.” Additionally, to uphold to a higher degree of anonymity for each participant’s identity, the personal pronoun of “she” will be utilized throughout the remaining chapters. The choice to utilize the personal pronoun “she” does not signify the gender of the participants (gender played no role in the research questions advanced); rather, it
provides the reader a more personalized glimpse into the experiences and perceptions of the participants.

As Chapter III discussed, the research participants provide a purposeful sample of K-8 mathematics methods teachers, demonstrating variability in teaching experience, education, and expertise (Wild and Pfannkuch, 1999). Such variability provides but a glimpse into the experiences and perceptions of K-8 mathematics teacher educators related to statistics. The participant introductions advanced on the preceding pages, along with Table 2, provides demographic information capturing the information solicited from the participants on the Demographic Survey (Appendix B).

**Participant Introductions**

The following paragraphs will provide a personalized glimpse into the professional backgrounds of the participants involved in the study. Once again, the use of “she” within the scope of the descriptions presented is not an indication of gender.

*P-1* was a 7-12 math teacher for 19 years. Leading up to the teaching profession, *P-1* completed an undergraduate degree in junior high school and elementary school mathematics. During the course of *P-1*’s career in education, her teaching experiences were diverse and spanned from business math to Advanced Placement (AP) calculus. While concurrently teaching, *P-1* earned a Master of Education degree in mathematics and also took 24 additional coursework hours in mathematics content over and above the degree requirements. Statistics coursework, per se, did not enter into *P-1*’s prospectus
until her Doctor of Philosophy (Ph.D.) program, where she studied mathematics education with a concentration in research and measurement. She holds that her areas of expertise are in K-12 mathematics content, teaching developmentally, gender issues in mathematics, and teaching for conceptual understandings. *P-I* has taught a mathematics methods course for K-12 preservice teachers for the past 18 years and is a tenured faculty member at the institution where she presently instructs. Of the participants, *P-I* may have the most diverse higher education teaching background. She has taught math methods for elementary majors, math methods for secondary majors, qualitative research methods, quantitative research methods, math content courses for education majors (e.g. Elementary Mathematics I), and math content courses for non-education majors (e.g. Pre-calculus).

*P-2* was a 7-12 math teacher for 29 years. *P-2* completed an undergraduate degree in mathematics education. During the earlier portion of *P-2*’s career, she earned a Master of Education degree in mathematics education. During *P-2*’s public school teaching career, she instructed all levels of high school mathematics, but indicated a particular fondness for teaching AP calculus and statistics, the latter of which was offered for university credit. While an inservice teacher, *P-2* was actively involved with an ongoing professional development initiative related to advancing statistics education at a local university spanning several summers. After retiring from public education, *P-2* began a Doctor of Education (Ed.D.) program in mathematics education where she worked on professional development initiatives related to mathematics content for secondary teachers, mathematics pedagogy, and the integration of instructional
technology in mathematics lessons. In P-2’s doctoral program, she had several educational statistics courses and was also part of a professional development initiative related to statistics while she was a public school teacher. Her areas of expertise reside in mathematics pedagogy and the integration of technology in instruction. Further, P-2 is a tenure-track faculty member at her institution, where she serves in her role as a mathematics educator (by title) in the department of mathematics. She has been teaching in higher education for three years and taught K-8 math methods each semester during this time. At P-2’s institution she has taught math methods for elementary majors, math methods for middle school majors, math methods for secondary majors, math content courses for education majors (e.g. Elementary Math I), and math content courses for non-education majors (e.g. Business Statistics).

P-3 heralds 13 years of 7-12 mathematics teaching experience. She completed a Bachelor of Science in mathematics education and completed three (3) undergraduate courses in mathematical statistics. During P-3’s tenure as a high school teacher, she taught a myriad of upper level mathematics, including algebra II, algebra III/trigonometry, calculus, and statistics. During the early portion of P-3’s teaching experience, she completed a Master of Education degree in mathematics education. Additionally, like P-2, she was also involved in the earlier portion of her career in a statistics education professional development program spanning several summers for middle school and high school teachers. P-3 was asked to teach several courses in this program because of her success and knowledge. While teaching, P-3 began coursework in partial fulfillment of a Doctor of Education (D.Ed.) degree in curriculum and
instruction. Shortly after completing her doctoral program, she received an offer at a local university to teach math methods for preservice elementary and middle school majors. P-3’s proclaimed area of expertise is teaching mathematics with a constructivist approach. During her six year experience as a tenured faculty member in the college of education, she has had the opportunities to teach K-8 methods courses for preservice teachers. In fact, this is the only course that P-3 has taught at her respective institution of higher education.

Table 2 on the following pages provides a structural snapshot of several significant demographic features maintained by the participants. While Table 2 does provide insight into the backgrounds of the participants, there are several details particular to it that must be discussed for purposes of clarity and accuracy.

First, specific years of K-12 teaching experience and years of experience teaching the K-8 math methods course are expressed in increments of five years (e.g. between 10 to 15 years) and represent a closed interval for that period of time. It was undesirable to indicate the exact period of tenure due to potential compromises such an indication may make to anonymity.

Additionally, undergraduate coursework in statistics is listed in Table 2, but graduate coursework in statistics was not. None of the participants involved in this study took graduate level statistics coursework from a department of mathematics or statistics. Yet, as the participant introductions detailed and the balance of Chapter IV will explore, all of the participants had some background in non-calculus based statistics, such as educational statistics, workshop statistics for K-12 teachers, statistics for research, and
the like. Ultimately not including a piece related to graduate level statistics, while at first may leave the reader longing for additional information, promotes uniformity while not over-complicating a rather convenient rendering of the participants.

Finally, Table 2 indicates the duration of time that each participant has taught K-8 math methods classes. While there was not an in-depth audit conducted to assess the credibility of such claims, it is assumed by the researcher that data was presented to the researcher, by the participants, in the most accurate and honest method. Also, it is only fair to mention that while one of the participants may have had more years of experience teaching K-8 math methods, it is safe to assume that another participant with less years of seniority may have actually taught more sections of the methods course. Thus, years experience may not necessarily imply overall experience.
Table 2: Demographic Information of Research Participants

<table>
<thead>
<tr>
<th></th>
<th>P-1</th>
<th>P-2</th>
<th>P-3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Undergraduate Degree</strong></td>
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<td>Bachelor of Science in Mathematics Education</td>
<td>Bachelor of Science in Mathematics Education</td>
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<td>12</td>
<td>13</td>
</tr>
<tr>
<td><strong>Undergraduate Statistics Courses</strong></td>
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<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Masters Degree</strong></td>
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<td>Masters of Education in Secondary Mathematics Education</td>
<td>Masters of Education in Mathematics Education</td>
</tr>
<tr>
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<td>Mathematics Education</td>
<td>Curriculum &amp; Instruction</td>
</tr>
<tr>
<td><strong>Doctoral Degree Minor or Cognate</strong></td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Proclaimed Areas of Expertise</strong></td>
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<td>K-12 Mathematics Content; Mathematics Pedagogy; Integration of Technology</td>
<td>Teaching Mathematics with a Constructivist Approach</td>
</tr>
<tr>
<td><strong>Academic Rank</strong></td>
<td>Tenured Faculty</td>
<td>Tenure-Track Faculty</td>
<td>Tenured Faculty</td>
</tr>
<tr>
<td><strong>Past K-12 Teaching Experience and Duration</strong></td>
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<td>Yes; 25 to 30 Years</td>
<td>Yes; 10 to 15 Years</td>
</tr>
<tr>
<td><strong>Areas of Certification</strong></td>
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<td><strong>P-2</strong></td>
<td><strong>P-3</strong></td>
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<td>---------------------------</td>
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<td>K-12 Mathematics; Social Sciences; General Science</td>
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<th><strong>P-3</strong></th>
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<td>College of Education</td>
<td>Mathematics Department</td>
<td>College of Education</td>
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<th><strong>P-2</strong></th>
<th><strong>P-3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Methods for Elementary Majors; Math Methods for Secondary Majors; Qualitative Research; Quantitative Research; Math Content Courses for Education Majors; Math Content Courses for Non-Education Majors</td>
<td>Math Methods for Elementary Majors; Math Methods for Secondary Majors; Math Methods for Middle School Majors; Math Content Courses for Education Majors; Math Content Courses for Non-Education Majors</td>
<td>Math Methods for Elementary Majors</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<th><strong>Taught K-8 Math Methods in the Last Two Years?</strong></th>
<th><strong>P-1</strong></th>
<th><strong>P-2</strong></th>
<th><strong>P-3</strong></th>
</tr>
</thead>
<tbody>
<tr>
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<td>Yes</td>
<td>Yes</td>
<td></td>
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<table>
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<tr>
<th><strong>Duration of Teaching K-8 Math Methods</strong></th>
<th><strong>P-1</strong></th>
<th><strong>P-2</strong></th>
<th><strong>P-3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>15 to 20 Years</td>
<td>1 to 5 Years</td>
<td>5 to 10 Years</td>
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<table>
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<th><strong>Math Methods Courses Taught in</strong></th>
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<th><strong>P-2</strong></th>
<th><strong>P-3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Education</td>
<td>Department of Mathematics</td>
<td>College of Education</td>
<td></td>
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<thead>
<tr>
<th><strong>Self-Rated Proficiency (1 – 5) in K-8 topics Related to:</strong></th>
<th><strong>P-1</strong></th>
<th><strong>P-2</strong></th>
<th><strong>P-3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number &amp; Operations (5); Measurement (5); Geometry (5); Algebraic Concepts (5); Data Analysis &amp; Probability (5)</td>
<td>Number &amp; Operations (4); Measurement (4); Geometry (5); Algebraic Concepts (5); Data Analysis &amp; Probability (5)</td>
<td>Number &amp; Operations (4); Measurement (3); Geometry (3); Algebraic Concepts (4); Data Analysis &amp; Probability (4)</td>
<td></td>
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</tbody>
</table>
Findings

The contents of this chapter will follow a prescribed format that follows a structural outline of the nature of the interview itself. Participants were asked a total of nine (9) questions related to their experiences and perceptions of statistics in the K-8 mathematics methods course for preservice teachers. Each question is provided as well as an overview of the question and the key points that emerged from the analysis of the interview data. The key points stem from each question because they are particular to the nature of the question, and are provided within the descriptive portrait of the question.

While Chapter V will seek to summarize the overall essences of the participants as prevailing Key Points, this particular chapter will seek to capture Key Points particular to each individual question. One will notice that block quotations are intentionally used to provide the reader with an intimate positioning of the participants’ voice, as opposed to a truncated snapshot of a sliver of data. This will provide the reader a more holistic perception of the participants’ thoughts relative to each question, while also contributing to the strength of the interpretative process.

**Question 1: How important is statistics in the K-8 curriculum?**

Regarding the importance of statistics in the K-8 curriculum, participants described experiences and perceptions into two key points. Specifically, interviewees:
(A) Acknowledged the importance of engaging pre-service teachers in statistics in the K-8 methods class and

(B) De-emphasized content-specific understanding and a shift towards a general philosophy of teaching mathematics.

**Key Point A: Professors acknowledge the importance of statistics**

Two of the participants (P-1 and P-2) acknowledged the importance of statistics education in the early years of elementary curriculum and stressed the early introduction of statistical activities for K-8 learners. Throughout their discussion, they also alluded to the evolving nature of statistics education from a formerly curricular afterthought to currently an academic mainstay with significant importance.

Statistics is huge because at one time it was something that you didn’t study until you got to grad school, maybe you took some undergraduate classes in statistics but statistics today plays a major role; it has a major impact on elementary and junior high curriculum simply because we have gotten into this thought and I think the Common Core reinforces that it has to be spiraling. We introduce concepts like algebra and data collection in the early grades, like in first grade, but that’s the beginning of moving on to those types of things as [students] get further on in their careers, so that they will gather candy valentine hearts, or what’s their favorite color, or they will sort the little cereal pieces in a box of lucky charms and graph them… and do comparison statements like there are more clovers and there are rainbows or whatever you have them looking at. (P-1)

Another participant, P-2, discusses:

I think statistics and data analysis is useful and should be integrated in the other content areas in algebra and even geometry and it should at least be something that is not saved for the end of the year if there is time. It’s more than that. On a scale of 1 to 5, statistics is a 5. (P-2)

In this particular key point, these mathematics teacher educators discussed, their perceived importance of addressing statistics education topics in their methods classes.
As P-1 and P-2 both discussed, statistics ideas are relevant in the K-8 curriculum and are “spiraling” (P-1) in levels of sophistication and “integrated” (P-2) to other topics in mathematics. In a related sense, P-1 held that statistics education has also had an evolving presence in the K-8 curriculum, while P-2 contends that statistics should receive thorough treatment in the K-8 curriculum.

**Key Point B: A de-emphasis of content-specific understanding and a shift towards a general philosophy of teaching mathematics**

P-3 perceived the purpose of a methods class to be an experience geared towards preservice teachers being exposed to a “philosophy” of teaching mathematics that is not particularly manifested in particular topics in mathematics and statistics.

In the methods class, I believe it’s more important to give the students a general, solid philosophy of teaching mathematics and not as much specific instruction on specific content areas…just based on the limited time we have with them. It’s sort of the mile wide, inch deep philosophy that NCTM puts out there. It’s very similar with the methods class. We could cover a lot of the topic very shallow like or we could really focus in on the general philosophy of trying to get students to get to see math taught in a different manner than stand up there and lecture. So when you’re given 37 hours to get students to change their view of how math can be taught, I believe that we need to get them to focus on getting them to thinking about a different type of pedagogy as opposed to a specific math content area. Hopefully then they will take that philosophy and apply it to a different content area…statistics as you’re referring to. (P-3)

Through this method of getting students “thinking about a different type of pedagogy,” the same professor indicated that:

I don’t believe that [statistics] is emphasized very much by any means. We have a relatively small faculty…I don’t know, we have a couple of faculty that would teach K-8 math methods and it might be a topic for a class period, to be honest with you, in the methods course. (P-3)
Here $P$-3 maintains that she does not feel as though the explicit purpose of a K-8 math methods course is to present distinct content topics and stresses that statistics is not a large portion of the curriculum at her institution in the K-8 methods course. As previously mentioned, $P$-3 persists that the K-8 math methods courses should expose students with a generalized philosophy for their future teaching practices related to mathematics.

The two key points present in Question 1 indicate a divergence in the particular purpose of a mathematics methods course for K-8 preservice teachers respective to the representation and presence of statistics. $P$-1 and $P$-2 upheld that the methods course should expose students to topics related to data analysis and statistics as an important part of K-8 curricula. To a different end, $P$-3 maintains that students should be exposed to the broader concepts of teaching mathematics through meaningful learning opportunities while the professor provides demonstrations to shape students’ perception of a “better way” to teach mathematics.

**Question 2: How do you relate content, projects, and assessments to statistics concepts in your methods class?**

To varying degrees, each participant addressed content, projects, and assessments in their math methods class, in terms of the teaching materials they prepare for their preservice teachers for purposes of learning or reviewing content or pedagogical knowledge. Four key points emerged from this particular question. They are
(A) Mathematics methods students’ preparation in topics related to statistics is nebulous;

(B) There are disparities in the content addressed in math methods classes for preservice K-8 teacher candidates;

(C) Participants utilize an interpretative task or tasks as a project related to statistics in their K-8 methods class; and

(D) Formally assessing K-8 teacher candidates’ knowledge of statistics varies between participants.

**Key Point A: Mathematics methods students’ preparation in topics related to statistics is nebulous.**

Each professor discussed some degree of preservice teacher preparation shortcoming in terms of content knowledge of statistical notions with respect to the students entering their methods course. When asked about the preparation of the teacher candidates entering the methods course, one professor explains:

> It depends, but I would say that they come in with the procedural knowledge. They can go through the motions but they don’t know why and they don’t know what it means when they are finding the mean or finding the median, or what the difference is. They can construct graphs, but they haven’t thought about what it really means; they haven’t gone to the interpretation part. They haven’t gone to the higher level. I am big on a conceptual understanding of what does mean really mean, what does variability mean…if a graph is skewed, what does that tell you about your data, that type of thing. (*P*-2)

At the institution where *P*-2 instructs, there is an entire segment of one content course that is solely dedicated to addressing common statistics and data analysis topics that are included in most K-8 curriculums. This participant clearly established that students entering the methods course were very competent with a procedural knowledge
of relevant ideas. *P-2* maintained that her role was one of developing statistical reasoning tasks to extend her students’ conception of statistical notions. Yet, *P-1* and *P-3* purport that math method students’ content knowledge of eligible K-8 content falls along a wide range of competency, from ill prepared to well adapted. However, in terms of the content background framed for the teacher candidates in each of the prerequisite mathematics courses leading up to the methods class, it appears that in some cases statistics is, at best, an afterthought.

I looked at the content topics for the courses that prepare students for the methods class that our teacher candidates have to pass to get into the methods course and I mostly saw a lot of number theory and such. I didn’t see…well, maybe the equivalent of a class period dedicated to statistics. (*P-3*)

*P-1* discusses a similar level of expected student preparation as *P-2*, yet there appears to be a disparity between the intended curriculum and the enacted curriculum in the mathematics content courses leading up to the methods class.

Well at this institution the students have to take a math course that has the content with data analysis and statistics in it. And it covers the material that most people would learn or most children would learn through the middle grades, up thru at least sixth grade. But unfortunately not all the faculty who teach those math classes covers the content. They tend to make the class their own and don’t touch on it at all. And so that’s of the issues with the content. And I think you want me to talk about the methods class as well…I do cover content in my methods classes because that’s the only way I know [students] will get what they need. (*P-1*)

To varying degrees, the participants agreed that some knowledge of statistics and data analysis is required for preservice teachers entering a math methods course. While *P-2* spoke matter-of-factly to a definitive statistics and data analysis core that students entering the methods course were required to complete, *P-3* addresses that very little statistical and data analysis topics are covered as requisite understandings for enrollment
into the methods class. Finally, P-1 acknowledged that while there were course objectives in one of the mathematics classes leading up to the method course that addressed statistics and data analysis topics, experience has led this participant to perceive that there is not a high degree of fidelity with respect to addressing the course outcomes of the preparatory math content course from numerous members of the department appointed to instruct the course. Subsequently, P-1 has felt the need to re-introduce some of the basic statistics and data analysis topics (e.g. mean, box-and-whisker plots, etc.) to the math methods class students.

**Key Point B: There are disparities in the overall content addressed in math methods classes for preservice K-8 teacher candidates.**

Statistical content within the methods course described by the participants spanned an interesting array of topics and applications. P-2 discussed a very structured and methodological approach to looking at content in the K-8 math methods curriculum:

In the methods courses I teach, I kind of follow the GAISE framework for statistical problem solving in terms of formulate questions, collecting data, analyzing data, and interpretation so that all always the backbone of what I teach. And so then we talk about formulating questions, collecting data, we talk about importance of random selection and bias. In terms of interpreting or gathering, we focus on graphical and numerical summaries. (P-2)

Throughout the discussion, P-2 referenced the GAISE (Guidelines for Assessment and Instruction in Statistics Education) framework numerous times and spoke of the importance of immersing the K-8 preservice teacher candidate in the process of being an informed consumer of data. Moreover, this instructor also addressed the important role content plays in her methods class related to statistics.
What I focus on even though they may only be teaching up to fourth grade or whatever, they need a deeper knowledge to understand various concepts. For example, when calculating the mean, we look at the mean as leveling off and the mean as balance. And we do hands-on activities with that. We talk about how important variability is as well as graphical displays. We go beyond what would be taught in an elementary classroom and we talk about which graphs are appropriate for which type of data, even though some graphs are appropriate for more than one type. And then in terms of interpreting the results, I have them look at both their numerical summaries and their graphical representation to come up with solutions. (P-2)

It was critical to P-2 that statistical notions congruent with K-8 curricula are developed more thoroughly in her methods class in such a way that allows pre-service teachers to understand the conceptual undergirding of topics. Also, this participant did not only address statistical notions for reporting data, but drew upon the reporting of statistical information and subsequently best practices in reporting this information (e.g. the common features and differences between bar graphs and histograms).

P-1 indicates that statistical topics in the K-8 curriculum must be introduced early in formal education, stating that “it’s a gradual process…it has to be a gradual process where it didn’t use to be.” She states:

I know by the time kids hit 6th grade they’re already looking at box plots they are already calculating mean, median, mode, range…they are starting to look at standard deviation in junior high school so statistics is a very, very important thing especially in the world that they live in today because high school students need to have the understanding of statistics. When they leave high school, even if they are not going on to college there are things that they need to know that applies to daily living. (P-1)

This “gradual process” was reinforced through a developmental lens of extending an awareness of statistics into high school and ultimately as an educated citizen, with emphasis placed on seeing statistics concepts in daily life. In this way, P-1 frames her
response to this question in terms of the K-12 learner and adult, whereas P-2 spoke more directly to the preservice teacher.

When P-1 was asked about the content addressed in the K-8 math methods class, there was first a general discussion of the participant’s experiences as a teacher.

I usually take a totally different approach to teaching anything (laughs) than the standard person would do. I was not a typical high school teacher or junior high teacher for the two years I did teach in the junior high. I didn’t follow a textbook. I followed the way the students think and the way they understood the material in class. I think those things have heavily contributed to how I teach my methods class now, as far as believing that not only do I need to know how and why I do some math the way I do, but also what my students need to know as well. Math and statistics does not have to be a standard, traditional, or algorithmic way of thinking. (P-1)

At the time when the interview took place with P-1, the final week of coursework came to a close and students were entering final exam week. She drew upon the content that was covered in the last week of the methods course that dealt with statistics, which is expressed through outcomes, not necessarily the concept formations of the preservice teachers.

This past week we got to look at data analysis and statistics and I know that like I said, I know that not all of my students are getting that background so I go through a little bit of content with them….how do you do a box and whisker plot? You know, how do you do the stem and leaf plot? How do you look at this information? How can you find out mean, median, mode, range and that type of thing? What’s a standard deviation? (P-1)

Interestingly, P-1 also addressed the relationship between statistics for the purposes of eligible content awareness for the K-8 learner, while also looking at the knowledge and ability of the teacher to interpret standardized test score data.

I also bring up in my methods classes and look at stanine scores. What’s a stanine score? What’s a percentile rank? What does that mean? What does it mean when you talk about a bell curve? These are things that teachers need to know when
they are in the classroom and they have to interpret data and interpret standardized test data to a parent and they don’t even know. And the other thing is that there are a lot of standardized testing companies that don’t report information correctly…one grad student told me one time that the testing company that their school district used told the teachers “oh the scores are great, the scores were in the first quartile.” And you know first quartile is not good! (P-1)

P-1 continues, now with the intention of readdressing the notion of statistics for the masses while also framing statistics through the lens of the teacher and the K-8 learner. Subsequently, she discusses the need for preservice teachers to be aware of the content while also being aware of the pedagogical backbone of statistical notions.

So there are some real issues out there with what the public knows this sort of thing [statistics]. So in my methods classes I do teach some of the content again because some of the students don’t get it when they take the math class and I do go a little bit beyond that content. And we also talk about ‘where does this go?’ and ‘what do you need to know as a teacher?’ I have them look at not just what your kids are going to learn in the classroom, but also what do you as a teacher need to know? (P-1)

Unique to the other participants, P-1 upheld the importance of teachers being able to interpret data and basic statistical notions such as stanine scores and measures of ranking for the purposes of interpreting information for classroom decisions and subsequently conveying this information to parents and other stakeholders. This statement is congruent with her robust coursework background in educational research and measurement.

P-3 holds that statistical concepts are integrated in learning tasks presented to students in the K-8 math methods class.

I sort of had an idea because of the questions on the questionnaire that you would be talking about statistics and thought about it on the drive up here, but it’s going to be brief. I can give you an example of where statistics play a role in my
methods class. That is that I embed some statistical concepts within other teaching areas. In other words, I have an activity in which I am dealing with assessment and I am trying to get student to think that if you give the k-8 learners a good task, as opposed to just a worksheet with 15 of the same or similar problems. (P-3)

Statistical content was not stressed by P-3 as an area of particular emphasis in the K-8 math methods course. Yet, she provided an example of how statistical content is embedded in her methods course.

If you give them a good problematic task, then you can assess students and learners in a lot of different areas...so in that task, I give them a sample task, and that task involves mean, median, mode, range and it’s an open-ended, descriptive statistics task. And then I expand on that task whenever I talk about differentiation, after some presentation of different ways to differentiate, I ask them to differentiate that original task again that dealt with mean, median, mode, range, and statistical graphs...bar graphs, things like that and I ask them to differentiate it. And that’s the extent of the content that I do unless, for some reason, I get a little extra time and I will do some interesting activities. Instead of teaching mean as adding up the numbers and dividing by the number of numbers, I try to get them to think about mean as a balancing or a fair share type application as opposed to just then, you know, the algorithm or the procedure. (P-3)

In this particular description and the surrounding conversation, it was most clear that P-3 is foremost concerned about offering students a pedagogical structure to particular “problematic tasks,” which, in this case, happened to include statistical concepts. It can also be observed that that P-3 possesses knowledge of a conceptual aspect of the arithmetic mean in her textural description of statistical content, where she describes it as a notion of fair share or mathematical point of balance, yet did not necessarily convey these notions related to the mean as particular skills that preservice teachers needed to possess.

Key Point 2 of Question 2 revealed differences in how the three (3) K-8 math methods professors address statistical content in their respective courses. When asked
about the statistical content presented in K-8 methods class, \textit{P-1} discusses the idea of introducing some degree of eligible content along with introducing preservice teacher candidates to scaled scores and those that are reported by major standardized testing companies. \textit{P-2} provided reference to the GAISE framework and spoke to the role of exposing preservice teachers to a skill set of describing and reporting statistical findings and outcomes. Finally, \textit{P-3} indicates that statistical content, in and of itself, is not particularly addressed in the methods class and prefers to frame the material covered in class in terms of presenting subject matter in pedagogically-appropriate ways, which may include some aspects of statistical content. Yet, \textit{P-3} was much more focused on students having the opportunity to observe rich instructional modeling in the methods course, and was much more arbitrary in her treatment of content within her model lessons.

It is evident that each participant may reflect the extent of statistical content covered in their K-8 math methods course related to their prior experiences as a scholar and educator, along with their perceptions of the goals and objectives of a math methods class. While subsequent questions will more thoroughly address and expand on the existence of such relations, one may initially begin to consider such factors as undergraduate or graduate coursework experiences, teaching and professional development factors, and academic interests may play substantial roles in such perceptions.
**Key Point C:** Professors engage preservice teachers in a statistics-related project that involves an interpretative task or tasks as part of a project in their K-8 methods class.

*P-1* described that while time for projects is limited in the methods course for preservice teachers in a very general sense, statistics is emphasized through an activity that can span multiple grade levels and multiple objectives.

You know I usually have some activity … we do a skittle project. We did the skittle graphs so we get to see how this could be applied. Like a look at something as simple as the color of skittles at the first or second grade and carry this through middle school and actually look at the statistics. I ask questions like why does everyone like red? Do you make more red or fewer red so they buy more skittles and toss the rest out? Who knows? To look at that kind of information I think is really important because it gets kids thinking about the data. (*P-1*)

As described, *P-1* felt strongly that the preservice teachers should answer rather subjective questions about the data in order to become more immersed in the process of “thinking about the data” and reading beyond the data.

*P-2* described preservice teacher projects in terms of two particular parts. The first set of projects related to statistics involves numerous assorted tasks representative of the K-8 grade-level span of eligible content, similar to what K-8 learners would engage in. Yet the second project deals with a comprehensive topic picked by the student and approved by the professor. She describes:

Well they have individual assignments on things like random sampling and numerical summary, the different graphs, but they also have data analysis project that they formulate their question and then I approve those questions to make sure they are appropriate and it has to be a question for which they don’t already know the answer to and then go through the process, the four step process, for completing that project and they are graded based on the points for each of the four categories from GAISE. (*P-2*)
This particular participant felt that it was important for preservice teacher candidates to observe the “big picture” of collecting, summarizing, reporting, and interpreting data through an authentic task, much like they could present to their very own students in the coming years. In this way, it was P-2’s desire that the preservice teachers would have the opportunity to conceive this project through the lens of a consumer of the findings and also from a teacher’s point of view, in terms of students’ knowledge formation and misconceptions, as well as questioning strategies and possible project extensions.

This would, in the participant’s words, “give [math methods] students a chance to witness the statistical process at work.” (P-2).

The final participant, P-3, discussed projects in terms of (1) class assignments and (2) field component experiences that the K-8 math methods students are or may be exposed to during the course. The first component this professor discusses is class assignments. The participant states:

I give all them [preservice math methods students] an in-class project and that is to take this task and try it themselves. So I give them this task; basically it’s a task in which the K-8 learners are given a table of three (3) candy machines and the candy machines are supposed to dispense 25 pieces of candy per dollar and it gives five (5) trials, I put in a dollar, how many pieces of candy do I get out and they have to make a recommendation of which one of the machines that their school should buy. So they are looking for the mean, the median, and the mode to be 25 and the range to be small, so that’s the content of it. So they try the task, we talk about the task, we talk about solutions, they differentiated the task and they all get that…(P-3)

When asked about the anticipated outcomes of this particular project, P-3 provided a candid rationale:

It’s an open-book assignment. Really what I am looking for them to do is to go to our textbook and look in the chapter on probability and go through the process of
trying to find out what our author says regarding probability. They are gaining a little bit of insight into how better to teach it and then they are finding a task that our author would suggest that would address this specific question. And again, it’s getting at the idea that if you do a trial, whether if you are flipping a coin, and you would expect that out of 20 trials, that you would get 10 heads and 10 tails and you want to get students to realize that that doesn’t always happen so why doesn’t that happen?

How would you as a teacher, get the students to think about probability in a different way? And again, hoping they’ll realize that maybe if I give, you know, 10 groups of students have them do 20 trial and then bringing all of the trials together showing that as you get more trials that the theoretical probability and the experimental probability will become closer together and that’s what I am hoping the outcome of that particular task is. (P-3)

In this textural description, it is evident that P-3 seeks to make clear to preservice math methods students salient probability ideas and utilizes the assigned textbook for the course to serve as a springboard to advance this idea, at least at the onset, with the teacher candidates. The textbook, P-3 held, discusses not only the mathematical explanation behind the activity, but also how questions and activities can promote student learning and understanding.

She maintained that “There are not really any projects related to mean, median, mode, or range that I use” (P-3). In this way, P-3 discussed the corpus of relevant statistical topics in the K-8 curriculum as relating to summary statistics, which does not necessarily suggest that statistical ideas are not addressed in the class, but does signify that this participant does not explicitly make accommodations for summary statistics with respect to course projects.

The second component that P-3 discussed was an integrated field component for a period of three (3) weeks in the math methods class.

…beyond that, there is an associated field component. If they [preservice math methods students] choose a data analysis or probability or statistics topic or their
cooperating teacher asks them to do something with regard to mean, median, mode, or range, that’s about it. Maybe other than data analysis as far as displaying and graphing, those are the only lesson I’ve seen, and that’s hit and miss. Maybe 1 or 2 teacher candidates would get that assignment…(P-3)

During this field experience, as P-3 points out, the preservice teacher is largely bound to the classroom curriculum that is in place, as well as the grade level goals and objectives of the school district respective to their placement. Ultimately, as she holds, most preservice teacher candidates do not experience exposure to statistical ideas in this field experience. To this end, this field experience is one where the student largely observes, with the exception of several co-teaching opportunities and one individual lesson that they are expected to present.

Key Point 3 of Question 2 holds several examples of projects and assignments that the participants utilize to capture ideas about statistics that they themselves find important and meaningful for their K-8 preservice teacher candidates, insofar as their future roles as teachers. P-1 discussed the skittle graph project, P-2 outlined individual assignments along with a data analysis project, and P-3 drew upon a candy machine project.

**Key Point D: Formally assessing K-8 teacher candidates’ knowledge of statistics content and pedagogy varies between participants**

To this point in the chapter, participants have discussed statistical content and projects/assignments utilized in their math methods classes for preservice K-8 teachers. When the participants were asked to speak to their assessment practices related to statistics, responses varied greatly.
P-3 discussed that statistical topics were not a substantial portion of the scope of a methods course in terms of a need for formal assessment. Yet, the participant discussed:

On my final, although it hasn’t been this way for a couple of semesters, I gave students five problems for which they can choose two of them, and of the five, one of them is a probability problem in which they are asked, given a scenario, that you want to teach this concept relative to probability…the students are at this sort of understanding, how would you present this topic to them? I don’t know, I think it was probability and the law of large numbers. (P-3)

In the particular task described above, P-3 placed an emphasis on having the preservice K-8 teacher candidates frame a particular topic, related to probability task, utilizing an instructional method that is pedagogically appropriate. According to her discussion, there were no topics related to statistics on the K-8 math methods final exam.

Another participant, P-2, drew upon the significance that the cumulative statistics and data analysis project had in terms of capturing the teacher candidates’ knowledge of the relevant material.

In terms of assessments…well their project I count as a major assessment, but they also have quizzes and exams on the content. But I really think I understand their understanding by looking at the projects and how they interpret. That is, how they interpret and if they interpret their data. I want to see if they are able to read beyond the data. (P-2)

This participant went on to describe that she utilizes periodic quizzes and exams that cover notions relative to content and some of the conceptual aspects of teaching mathematics and statistics to K-8 learners (e.g. How would you explain to students how to find the product of fractions?). On such assessment instruments, the participant explained, a basis is established for what the teacher candidates know in terms of relevant content and related strategies for introducing certain statistical concepts in a pedagogically appropriate manner. Yet, as the previous caption suggests, P-2 holds a
high degree of fidelity in the small-scale research project that is completed under instructor supervision, where teacher candidates participate in the data collection process outlined by the GAISE.

P-I also utilizes quizzes and a summative final examination to assess the teacher candidates’ knowledge of content, as well as their ability to address various tasks from a pedagogical standpoint. She explains:

I have them read their graphs on my final exam. I had a question where I gave the students a box plot and they had to interpret it. I asked questions like “tell me what this means?” and “what is the range here?” “How do these things come about and explain that process?” So yes, that’s in there. I think to myself “if you can’t explain it, how can you teach it?” If you can’t let me know what you know about this picture or this graph then you’ll never be able to tell students. And sometimes I have them read the box and whisker plot and I give them a whole bunch of numbers and ask them to tell me quartiles and read beyond the normal limits and outliers. “So what is the information you can tell me?” and then go through and interpret it. But yes, I think it’s important that the more they can apply it in class hopefully they can take that to their own classroom. (P-I)

Within the scope of assessment, this participant champions the ability of teacher candidates to explain meanings behind notions of statistics. As P-I exclaims, “If you can’t explain it, how can you teach it?” Within the explanation of this participant, it can be observed that it is important for teacher candidates to work with data, including the interpretation of statistical displays and the negotiation of considering abnormal data. These tasks are captured on this participant’s final examination for K-8 preservice teachers.

Key Point 4 of Question 2 discusses the participants’ descriptions of assessment related to statistics topics in their K-8 math methods class. As this Key Point maintains, there is substantial variation between how the participants assess statistical knowledge in
their K-8 methods class, primarily from a conceptual perspective, but there was trace evidence that a statistical knowledge for teaching was tangentially discussed as well (e.g. \textit{P-1} asks preservice teachers to describe how they would teach particular statistical concepts, while \textit{P-2}’s large-scale project extends questions to the preservice teachers about the nature of statistical knowledge formation from a student’s perspective). As the textural descriptions reveal, \textit{P-1} and \textit{P-2} utilize formal assessments in the form of quizzes and examinations to assess students’ knowledge of content and pedagogy. Additionally, \textit{P-2} involves students in a statistics project to synthesize their understanding of the data collection process, congruent with the GAISE framework. Further, \textit{P-3} indicated that statistical content and adjacent topics related with statistical pedagogy was not formally assessed in the K-8 methods class during the current semester, contending that a “general philosophy” of good teaching practices is more important to deliberately address in the methods class than any one particular content area of mathematics.

\textbf{Question 3:} \textit{What is the big idea (or the biggest ideas) of statistics education in your K-8 math methods class? Why is this idea (or these ideas) important?}

This particular question provoked a variety of responses from the participants, along with presenting a fair share of challenges to the participants in forming a response. The descriptions provided by the participants provided the following Key Point:

\textbf{(A)} Preservice teachers’ understanding of statistical content is a crucial element in teaching statistics to K-8 students
Key Point A: Preservice teachers’ understanding of statistical content is a crucial element in teaching statistics to K-8 students

In the course of discussing this question, two participants (P-1 and P-2) advocated a need for preservice K-8 teachers to have a strong sense of understanding related to statistics and data analysis in terms of content knowledge. After much thought, one participant stated:

Biggest idea…Biggest idea k-8…The biggest idea…You know, sometimes I don’t know. I mean I cover a lot of things in my methods class and I try to hit the big ideas but sometimes I don’t know that the things that I want to get across really catches hold. I think a lot of my students still think that teaching math is just add, subtract, multiply, and divide, fractions, decimals, percents and it’s frustrating. I guess the biggest idea that I try to get across, I try to bring in examples of where they’ll [the preservice teacher, in order to convey such information to students] see this stuff in the real world, and it’s not just stuff that is dreamed up in their text book and their professor talks about in class…but show them. I pull a lot of stuff, I have transparencies and I’ve got some website that I use to show them how it’s being used in other areas and that their kids need be able to do that and that they need to be able to read it. So just, the big idea I guess is to understand. Statistics is not just a word. It has a lot of applications out there and they need to be somewhat familiar with them. But I don’t know how far that goes. There’s just not enough time. (P-1)

To this point in time during her discussion of the “big idea(s)” of teaching statistics, there was a tremendous amount of frustration revealed in P-1’s response to this question, and certainly not one directed idea. This participant discussed much frustration related to the preservice teachers’ knowledge of content and their overall preparation to enter the classroom as she continued with her response:

You know, it’s hard to get across in a methods class that statistics important because the preservice teachers need to realize that these are things that their kids are going to have to learn because they are going to go on to some skill and they are going to go on and do something and they have to be familiar with how to
read the information and how to interpret the data. I’m not real sure my students that my students know how to interpret all the data because I don’t know that they get enough background in content. Like I said, I know some of my students and come in and they don’t know a stem and leaf and box and whisker…they have never heard of this before.

You know, it’s really kind of hard when you basically have a 12 week class. You know, 37 contact hours to get all the stuff in you need to get in. It’s tough. I can’t tell you that I really believe that they are really strong in being able to analyze data and make inferences when leaving my class. We go through the process of what kinds of questions you would ask your students if you saw this graph or how would you read the data, read between the data, read beyond the data, but other than that as far as statistics background I would say that they are probably not that strong.

I wish we had a stronger program, I wish that we required students to take more math and more science classes. We don’t. We meet the state minimum. But, I think it would be more beneficial if they had more content background.

Unfortunately it’s not there. And like I said, there are classroom teachers that can’t tell you how to read a test score. And to me that’s an important thing. When you’re meeting with parents and are explaining how their kids are doing and the kinds of indicators that you have…I don’t know. (P-1)

An initial response aimed at stressing to preservice K-8 students in the math methods courses elements of statistical understanding gave way rather quickly to undertones of frustration with her students’ level of preparation in terms of content knowledge and her belief that many teacher candidates were leaving this class, to her dismay, with a minimal (at best) knowledge of the conceptual understandings that are championed for the K-8 students themselves. This dismay is directly rooted in the notion that preservice teachers must first possess conceptual understandings in order to convey and express these ideas in their future classrooms.

Another participant, P-2, drew upon the importance of understanding through a framework of daily living and citizenship:

I teach statistics at the college level for non-math, non-education majors. And when they get to that point when they are that old, they are like consumers. So they may never do research but I focus on, as an educated adult, an educated
citizen of the United State, you should to be able to read and question what you’re reading and through the lens of a general understanding and awareness. \((P-2)\)

When asked to speak further to this notion of a general awareness, the participant spent some time collecting and gathering her thoughts and then concluded:

See to me, the big ideas are for students to formulate questions appropriately, and then collecting data appropriately, and then knowing for the question you have what type of data to collect, and then once you have the data, how do you display it and which numerical procedures, if any, are appropriate, and then analyzing the results. So to me, that’s the overall picture then underneath each of those four, there are sub-big ideas. It’s most important that my students have a good understanding, though, of these main principles. \((P-2)\)

In this description, \(P-2\) maintained a high degree of fidelity to the ideas pertinent to the data collection and reporting process outlined by the GAISE.

Yet, \(P-3\) stated that “statistics topics do not occupy any portion of time worth mentioning in terms of big ideas in my class.” She did not feel that she covered statistics to a level that allowed her to speak elaborately to this question. However, after taking the time to also acknowledge that statistics “might be a missed opportunity in the K-8 curriculum,” \(P-3\) stated:

Statistics is used to describe the world around us and to make decisions. It’s about questions we ask about the world around us. It’s a powerful way to make decisions in our daily lives. And I would want them [preservice teachers] to leave the class with that idea...data skills...to make those decisions. I mean I would, again, have to go back and do some reading myself to remind myself, but I just think that, and that’s sort of my whole philosophy...big ideas. It’s what I want my students to leave my class with, a couple big ideas about whatever I am teaching. So if I had to say for statistics it would be the purpose of statistics in our daily lives and then give them some experiences in applying it. So hopefully those two things would make connections with them. And as they work forward in their careers, then can go back and solidify their understandings when the need to, you know, that’s the challenge. It’s difficult to prepare a teacher candidate to teach all of the content in K-8 curriculum. And it’s impossible in the time that we have. \((P-3)\)
During the course of framing the response to this question, P-3 was clear in stating that her response would be a “hypothetical one,” where she would discuss an idea that she did not directly practice. This participant makes a fairly strong case that statistics can be utilized as a tool for decision-making and preservice teachers subsequently need to be skilled in applying such knowledge. Additionally, P-3 feels that in-service teachers “can go back and solidify their understandings when the need to,” indicating that in-service teachers must seek out initiatives and opportunities to gain content knowledge during the early portions of their teaching career. Also, like numerous responses up to this point in time by P-3 and others, time and the lack of students’ content knowledge are perceived to stand in the way of adequately developing and preparing preservice teachers in the K-8 math methods course.

Question 3 provoked numerous responses. P-1 spoke to a need for preservice teachers in the K-8 math methods course to understand and interpret statistical information. P-2 addressed a similar emphasis of understanding, grounded in citizenship and common knowledge, while also summarizing the GAISE framework. Finally, P-3 spoke to a need for connections to big ideas related to decision making, but also preceded this response by acknowledging a lack of emphasis placed on statistical topics in the methods class. Question 3 is marked throughout by an undertone of relative uncertainty related to the big ideas (and what the big ideas entail) that preservice teachers must be exposed to, which precipitates further questions about the means and ends of statistical topics in K-8 teacher preparation.
Question 4: Are there any important distinctions between mathematics and statistics that you make to the students in your methods class?

There were several distinct avenues that the participants took in addressing Question 4. There were two Key Points that emerged from the data:

(A) Statistics is a branch of mathematics and is founded in context and
(B) Awareness of a distinction between mathematics and statistics but an inability to articulate the distinction.

Key Point A: Statistics is a branch of mathematics and is founded in context

Two participants (P-1 and P-2) discussed, to some extent, statistics as a branch of mathematics; however, their explanations were framed in different ways.

One participant, P-2, drew upon the divergent roles between mathematics and statistics. The participant explains:

The main distinction I make from the first day is mathematics and statistics are not the same thing. Whereas statistics looks or where mathematics looks at the structure behind numbers and variables and all those things, statistics looks at answering questions in a context in terms of some problem to be solved or something that you don’t know that you want to find out more about. So it’s numbers in a context; it’s data. Mathematics is not usually data, mathematics is more abstract. (P-2)

In this particular explanation, the participant explains that while both mathematics and statistics are typically conceived as “math” at the K-8 level, preservice teacher candidates must be aware that “statistics asks different questions than mathematics” (P-2).
\textit{P-I} also distinguished between mathematics and statistics, but heralded mathematics as the methodological backbone of statistics. This participant discusses:

You can’t do statistics without mathematics. I’m sorry. I mean, you can’t do a lot of chemistry without mathematics. I just guess in my mind statistics is like a branch off of mathematics. It’s an applied science. Like I said, I see it being applied, not so much theoretical research kind of stuff. I see statistics as an applied math and there are a lot of uses more than just shuffling numbers and plugging numbers into the computer to see what it prints out, using software, stuff like that. (\textit{P-I})

Obviously, this participant is very direct in identifying that statistics is grounded in the larger field of mathematics. Also, she draws upon the types of questions the two fields propose and comments on the departmental structuring between a standalone mathematics and statistics department with a joint department of mathematics and statistics.

I think in institutions that designate a department for math and a department for statistics, the statistics department is focused on real research where the mathematics department is more abstract reasoning. And that has been my personal experience as to why there’s a difference. There are still a lot of schools that have them together in one department and I don’t have a problem with that. I think when they are together in the same department, and it’s just my thinking, I think that they still can do their research applications but I think they are also more connected to real-world kinds of statistics but when they are off on their own, they kind of become totally independent. (\textit{P-I})

Here it is evident that \textit{P-I} feels as though statisticians and mathematicians pursue different areas of research. In separate departments, the participant contends, statisticians and mathematicians may look at more abstract, independent problems. However, in the case of a joint department of mathematics and statistics, the participant distinguishes between the applied problems of the statistician with the abstract reasoning of the mathematician.
Key Point B: Awareness of a distinction between mathematics and statistics, but an inability to articulate the distinction

P-3 acknowledged that there is a difference between mathematics and statistics. However, when the participant was asked if there were any distinctions made between mathematics and statistics in the K-8 methods class, she states:

It’s not made. I absolutely do not…it’s not something that I discuss, you know, a difference between mathematics and statistics. And to be honest with you, without a little review, I know there’s the difference and I know I have read it before, I don’t think I could give you a good explanation between the two. So, I guess…if I am not spending time on it, I don’t think that that is a great importance in the K-8 methods. I guess if I thought it was really important, I would fit it in there and make it a purposeful task each semester. (P-3)

It is clear that P-3 dispels any significance between making the distinction between mathematics and statistics salient in the K-8 math methods class. Moreover, this participant finds difficulty in distinguishing between mathematics and statistics and indicates that it would be necessary to review relevant literature and the like to become reacquainted with such a difference.

Question 4 reveals that two of the participants, P-1 and P-2, discuss the methodological and contextual differences between mathematics and statistics. Particularly, P-2 heralds the notion that statistics is “numbers in a context” and P-1 maintains that “You can’t do statistics without mathematics.” In this way, it is tenable to assert that P-1 regards statistics as a subset of mathematics, whereas P-2 holds statistics as a unique discipline that borrows from mathematics. Finally, P-3 asserts that while a
distinction between mathematics and statistics exists, any exact distinction is vague to her.

**Question 5:** *Is there a difference between how the teacher should understand statistical notions for the student and how they understand it for themselves?*

This particular question provoked a common accord among the participants. Specifically, the participants spoke through their own perceptions about how preservice K-8 teacher candidates need to be aware of content beyond the level, both in depth and breadth, that the students are expected to understand. Yet, the participants did not discuss that the preservice teachers may need to understand the content in necessarily different ways than how the K-8 learners themselves may be presented with the material. Particularly, the overarching Key Point made by the participants for Question 5 is:

(A) Preservice K-8 teacher candidates must understand content beyond the scope of what students are expected to understand.

**Key Point A:** *Preservice K-8 teacher candidates must understand content beyond the scope of what students are expected to understand*

Unlike secondary teachers who have specific learning outcomes for core courses taught through a mastery approach, P-2 keyed in on the notion that K-8 teachers must be well adept at knowing the statistics curriculum along the scope of a developmental
continuum, from the earliest introductions to the highest levels of understanding. She states:

That’s one thing that I fight with students about, not just in statistics but other areas as well, that just because might think you’re only ever going to teach first grade doesn’t mean that’s all the math that first mathematics isn’t everything you need to know. So, not only do these students… (pause) I first work with them in making sure they understand the content they’re going to teach at the level they are going to teach it, but sometimes that’s even an issue. So, yeah, they have to know that statistics…but it’s equally important that they have a deeper knowledge behind where those concepts came from, what you’re going to teach, and then what those contribute to in later grades. So you can’t just can’t live in your own little world of fourth grade math or third grade math, and think that’s all the statistics I need to know. And truthfully I think that as educated adults they should know quite a bit about statistical concepts. They should have a very deep understanding of statistical concepts because that will only help them be better teachers even if it’s early elementary school. (P-2)

P-2 opines that teachers need to have a deeper understanding of the statistical content and the undergirding of significant statistical ideas so that they are aware of “what those (statistical ideas) contribute to in later grades,” along with having a knowledge of the content beyond the here-and-now.

Let’s say we’re talking about median…so with third graders, an effective way to understand the median would be to, for example, if we wanted to find the median height for kids in the third grade classroom we could have them line up from shortest to tallest and then find the one exactly in the middle so that’s a good visual. But, for the teacher they have to that conceptual understanding but they, beyond that, they should know that things like, you know, half are below are the median and half are above the median, and how outliers really don’t affect the median, but they do affect the mean and why that happens. (P-2)

P-3 provides a strikingly similar response that echoes the need for preservice K-8 teachers to have a stronger knowledge of the content beyond what they may be teaching in the moment.

I think, you know, we all believe that teachers need to have knowledge beyond what they’re presenting to their students and certainly statistics would be included
in that. So, I believe that the big emphasis now in K-8 curriculum is for the K-8 learners not so much to create graphs and things like that, but to be able to interpret them and to be able to pose good questions. I mean, I believe that’s probably legitimate knowledge for the teacher candidates to know as well. But I don’t know that I would think that it’s important for these teacher candidates to know anything about inferential statistics at this stage. \( P-3 \)

\[ P-3 \] goes on to state:

And it’s a matter of what I believe they should know and what they believe they need to know because I think that both you and I know that a lot of teacher candidates come into a methods class and they just want fun activities, that’s what they expect. They think things like “I hope that when I come into this methods class that my professor will give me a lot of fun activities so I can make math fun” and so it’s that challenge that I think that teacher educators face. We want to try to move students from just realizing that there is a bunch of little activities that they can do and understanding why. I guess my idea is to focus on the why of the pedagogy more than the why of statistics in my methods class. \( P-3 \)

Throughout the course of dialogue with respect to this particular question, \( P-3 \) maintained a strong sense of disgust with how poorly prepared many preservice K-8 teacher candidates are in terms of their knowledge of mathematical content. This is also revealed in the participant’s consistent conveyance of the strong need for preservice teachers to have a structure and method for teaching mathematical ideas, suggesting that they need at least an elementary skill set for teaching mathematics. And while it certainly may seem as though \( P-3 \) dispels the importance of statistics education, a stronger undertone of “too much to accomplish and not enough time” superseded the conversation. She discusses her struggle with conveying significant ideas as a K-8 mathematics methods professor and reflects on the practice and difficulty of teaching a methods class.

I mean, we definitely have to present material differently. And maybe that’s some of the struggle that I have, not ever being in the elementary classroom. If I am trying to present something, an elementary topic, an elementary content topic to
my students…you know, I guess I struggle knowing that they know the content and so what can I do with this content to demonstrate good pedagogy and maybe a third grade lesson as opposed to just telling them it’s something that they might run into and have to teach. I would say in my classroom, and maybe now that you pose that question to some fault, I model a lot. I model a lot of lessons…because I think that’s what the candidates need at this point. You know, I wonder what stage they’re ready to think about the behind the scenes mathematical ideas as opposed to how it’s presented in the k-8 classroom. (P-3)

This participant openly stated that there is a tremendously frustrating challenge teaching a K-8 math methods class for preservice teachers. In a moment of silence after the preceding dialogue, P-3 concedes “I don’t always feel like I have this all figured out.”

The praxis of marrying together eligible content, teaching methods, sound pedagogy, and some sense of mathematical assessment seemed all too much for this participant (and also resounded particularly by P-1) to thoroughly and properly treat in a one-semester methods course.

Finally, P-1 addressed Question 5 through a similar lens as the one used by the other participants, stating that teachers needed to possess more knowledge of the relevant content than what they are currently presenting. However, this participant framed a response to this question that channeled back to a need for a conceptual understanding of data analysis to serve the purposes for analyzing and reporting data from standardized and normalized achievement assessments.

It depends on what grade they end up teaching as far as to what level they need to expect for their students or what they can present to their students. But at the same time, like I already mentioned, they need to know statistics beyond that level of their students because they are going to be involved, you know, their entire career, you know that, with test scores and bell curves and you know, standard deviations and so on and so forth. And it’s something that applies to them; there are things outside of school in their real-world lives if they think about it, there will be statistical information that is presented to them, whether they’re watching the news or investing in the stock market, or whatever they
might be doing. But yea, you know, like I said it depends on the grade they are teaching, where the kids are, and what needs to be covered at that grade level, but then also what they themselves know. So basically it’s my philosophy about everything – you need to know more than your students know because that’s how it’s supposed to be. (P-I)

As this participant indicates, an understanding of statistics for teachers for their respective students is perceived as much in data interpretation from a professional standpoint as a content-based perspective.

Question 5 captures the participants’ perception related to how the preservice teachers must understand content for themselves and how they also intend for their students to understand the content. In each case, the participants held that the teacher must understand statistical content in a deeper, more conceptual fashion from what is expected of the student in order to perceive instructional ends and foster the development of new knowledge structures.

**Question 6: Tell me what the following quote means to you: “To teach statistics well, it is not enough to understand the mathematical theory; it is not even enough to understand also the additional, non-mathematical theory of statistics”** (Moore, 1997, p. 803).

The use of a quotation, using another’s words, provided a glimpse into how the participants conceptualized the teaching of statistics. There were two Key Points that emerged from the corpus of data:
Key Point A: Participants address the need for conceptually and pedagogically sound methods for teaching statistics

The first Key Point reflected in the data finds the participants addressing the need for conceptually and pedagogically sound methods for teaching statistics. Each participant, in her own way, speaks through the provided quote to present her perceptions as a K-8 math methods professor. As P-1 maintains:

I think it means what I have been saying in and out today that there needs to be a real world understanding. There needs to be an application of the understandings. Because knowing the theory doesn’t mean that you know statistics and that you can apply it. And that the kids in kindergarten, the kids in fourth grade, the kids in eighth grade, the high school kids, umm, you know, it’s…it’s being able to see where it is applicable someplace outside of the book. The theory is fine, but it is just that kids need to see application, the teacher has to see it; it’s out there, everywhere. Pick up the paper, U.S. Today, that is one of the other activities that I do, look at all of the graphs…what does it mean, what’s it tell you, where did they go to get this information? It’s not just theory. (P-1)

P-1 provides a response to this quotation that is firmly grounded in the real-world applicability of statistics education in her role as a K-8 math methods professor. As she maintains, her math methods students must see beyond the theory of statistics to a level of authentic application and understanding.

Likewise, P-2 provides a similar explanation, drawing upon the perceived need for making learning meaningful for students.
Well to me the key word there is to “teach.” To teach statistics well...to me it means you could have the best statistician in the world, but that doesn’t mean that they are going to be a good...they aren’t going to be able to teach statistics well. You have to understand how children learn and the perquisite knowledge that they might need for one topic before they can go onto another topic and if they haven’t had that knowledge they’re not going to be successful at a higher level because they don’t have the basis to build on. To me, one of the things I like about teaching statistics is there so, so many ways you can represent things and do hands-on things to help kids learn rather than just saying here’s the formula, plug in the numbers. And with children, you don’t need to do that; there are minimal formulas you would need...it’s about representing information and there’s many ways you can do that with...by having or making human graphs, you can do that by using cubes and things like that to represent. You can do it on graph paper, you can do it on the smart board. And I don’t think...just because you know statistics that you would know to do that type of thing. (P-2)

P-2 maintains in this dialogue that emphasis must be first placed on the artisanship of the teaching practice. This participant maintains that skillful statistics teachers will exist in the space that occupies a thorough knowledge of statistical content with a strong knowledge of pedagogy.

Also, P-1 is reminded from the quote that many individuals have an imbalanced perspective of statistics and are fearfully unaware of its capability and purpose.

…you know people are afraid of statistics I think because they are shown just formulas and plug numbers into it to get a number. They just don’t know what it means. I think that scares them away; they don’t get to see the usefulness of statistics. They don’t even begin to understand and it drives me crazy when I hear even news reports and they say something about percent or statistically speaking and they don’t even know what they are saying. They say wrong information. Because they have never been there or if they were they were there through a theory class and they never really ever saw the application or the reason ability to figure out what they are saying in the first place. (P-1)

Yet another participant, P-3, provides a somewhat more hesitant and skeptical position of the shared quotation.

Well...(long pause)...it’s a, you know, it’s a quote that...is it’s pretty broad. I mean, the word “vague” almost comes to mind as well. You know, I’m thinking
about what it means to me in my teaching. If I were to maybe see the author and determine whether it’s someone that I am familiar with and if it’s someone whose opinion I value, I don’t know, but it’s someone who really believes statistics is very important and that to teach statistics you need to have the depth of knowledge about it. I’m sure this person wouldn’t approve of the way that teachers are being prepared nowadays. (P-3)

This participant, while not eager to provide initial, blind credibility to this quote, was earnest in explaining that verbalization and practice often live in two different worlds and that the art of teaching mathematics (and statistics) well is cured over much time and through the process of personal reflection. In short, P-3 drew a stark line in the sand between “walking the walk and talking the talk” when it comes to teaching practice. She continued:

Well, that’s sort of the battle I face with my teacher candidates because I believe that we jump into algorithms rather quickly and I believe that’s the case because that’s what they know. When I see this quote I am thinking like “what teacher would satisfy the person who wrote this quote? Like what K-8 teacher, what kind of education would they need to have to satisfy the author of this quote?” The typical teacher candidate that comes through this institution probably is a little bit of a math-phoebe in the K-8 level. They probably love kids and some of them are really strong mathematics students, but you know, but when I do an informal discussion of reflect on your experiences in math class, a lot of them say that “I hated it” and “I wasn’t any good at it” and so they fall back on what they know and what they know is procedures and facts. And I would imagine that’s a result them being taught procedures in the K-8 curriculum. (P-3)

P-3 shared this perception in an effort to state that there is no perfect teacher, and all teachers have flaws. The participant shared that many preservice teachers enter the classroom with a nominal set of skills and perhaps it is not entirely the job of the math methods professor to establish flawless instructional practices with preservice teachers. Rather, math methods professors can more reasonably be expected to convey ideas of good teaching practice to preservice and inservice teachers. The quotation in Question 6
also provoked P-3 to speak to the challenge of adopting a standards-based method of teaching.

I believe at least nowadays, and I spend a lot of time in the schools talking to K-8 teachers…they would justify that and say that they have to because they have to get through so much content because we are being pressured to meet certain standards for the tests. And I hear that when I do workshops and things and I present sort of a problem-based, NCTM standards-based type of teaching…problematic tasks, open-ended tasks. I hear “Oh, this is great, we would love to do, but we just don’t have time.” And I don’t know if that’s far off. So, definitely, there’s a lot of procedural mathematics being taught. (P-3)

The participant discusses here the merit of “problem-based, NCTM Standards-based type of teaching,” however; there is also an acknowledgement of time and expectation that seems to have a hovering realm of influence on how she conceptualizes the role of today’s K-8 teacher of mathematics. It this way, P-3 almost discusses reform-based teaching as a sort of impossible destination in terms of this weighty quotation.

Yet, this participant shares a vignette from the methods classroom, citing the shortcomings of a procedural approaching to teaching and learning mathematics. P-3 shares that the very nature of many classrooms that she visits as a university supervisor are failing her own preservice teachers.

And I can even tell you a story of when I was asking some teacher candidates to prepare a lesson and one of the lessons was on average and the teacher candidate came to my office and we were discussing the lesson and this teacher candidate just said, he came to my office and said “I know how to calculate average, but I just don’t know what the average is…I just don’t know…what is the average?” so this was a junior in college who add up all the numbers and divide by the number of the numbers but really didn’t understand it beyond that. I would say that might be an extreme case, but maybe not. (P-3)

It is clear that this participant is challenged and frustrated with the lack of ability and overall poor perceptions that many of her methods students enter the K-8 math methods
course holding about mathematics and statistics. During the course of this conversation, it was evident in the deep breaths, grimaces, and long pauses of P-3 that the K-8 math methods course is largely a mystery in terms of how to best execute a vision of preparing the best possible K-8 math teacher candidates to meet the educational challenges that they will inevitably face. That is, while initially toeing a strict line of modeling instructional strategies in the K-8 math methods class, this participant was beginning to question the very nature of the methods class. When asked whether or not P-3 felt as though the use of meaningful explanations of the underlying mathematical or statistical structure of the phenomena pushed the K-8 methods students to a more thorough level of understanding of the material, this participant replied:

I would like to say yes, but I don’t think so. When I do have that opportunity, again I model it as a lesson that they could give to their fourth graders. I guess I struggle on how to get them to see the mathematics within the demonstration. You know, this is something that they could do in the classroom, but I am not sure…I am not sure if they think of it beyond that moment in time…probably to my own fault that I don’t address it, even it is statistics or any other topic more in-depth, but to do that you cut something else out? Do you cut out a discussion of assessment? Do you cut out writing in mathematics? Do you cut out objectives? Do you cut out differentiation equity? You know, it’s a zero sum game. To add something you have to remove another and that’s the challenge.

I struggle, Mark. I struggle every class. I sit down, not necessarily every class session, but every semester. I look at the time that we have and the things that I would like to cover and shake my head and I just try to do the best with what we can. (P-3)

Overall, the use of Moore’s (1997, p. 803) quotation provided this participant the chance to speak to the constructs of good mathematics (and statistics) teaching; however, the most powerful emotions were elicited during the course of the conversation when P-3 considered much of what the methods class seeks to accomplish and the final products of the teacher preparation program.
Question 6 utilized the following quote: “To teach statistics well, it is not enough to understand the mathematical theory; it is not even enough to understand also the additional, non-mathematical theory of statistics” (Moore, 1997, p. 803). This quote provided telling responses from each of the participants. *P-1* spoke primarily to the need for application and understanding on the part of the K-8 teacher to thoroughly present statistics concepts in pedagogically sound ways. *P-2* addressed the praxis of teaching statistics. Specifically, *P-2* contended that good teachers have to see beyond the content of the present moment and know the instructional trajectories for future learning and concept development. Finally, Question 6 provoked a variety of perceptions from *P-3*. This participant was inspired by this quote to first challenge the potential of empty verbalization of idealistic thought, but then shifted towards a self-reflective piece where she raised questions between the enacted curriculum, strong expectations for classroom content coverage, and the question of what her own methods students really know and understand.

**Question 7:** *What coursework have you taken in statistics or statistics education and how has this shaped your perception of statistics as a K-8 math methods professor?*

Some degree of statistics coursework existed among each of the three participants. *P-1* and *P-2* had little experience with statistics as undergraduate students; however, *P-3* took numerous undergraduate mathematical statistics classes. None of the participants took graduate level, calculus-based mathematical statistics; yet each participant took
several graduate classes related to educational statistics (e.g. Statistics for Research, Quantitative Research, etc.).

Likewise, \(P-2\) and \(P-3\) were both intimately involved in the Statistics Education through Quantitative Literacy program in the 1990’s through a professional development grant. The Statistics Education through Quantitative Literacy program was geared to prepare in-service middle school and high school teachers with the tools and dispositions for integrating statistics and data analysis topics into current mathematics curricula. Additionally, \(P-1\) had a doctoral coursework concentration in research and measurement, with statistical literacy serving as the methodological backbone of this cognate. In sum, each participant felt as though their coursework and educational backgrounds played a strong role in shaping their role as a K-8 math methods professor. One Key Point saturated this question:

(A) K-8 math methods professors identified their statistics coursework as a significant contributor to their perception of statistics education in their methods classes

**Key Point 1:** K-8 math methods professors identified their statistics coursework as a significant contributor to their perception of statistics education in their methods classes

To varying extents, the participants indicated that the statistics coursework that they took played a significant role in shaping their perspectives as a K-8 methods professor. Also, coursework varied from largely mathematical statistics backgrounds (\(P-3\)) to nearly all educational statistics (\(P-1\) and \(P-2\)).
In P-1’s doctoral program, candidates were required to have a concentration of 24 hours in an approved field. This was referred to as a cognate. The cognate P-1 chose was research and measurement. This participant indicated that the program was taught through the educational psychology department “by educational statisticians…one from the University of Chicago and he was very, very good” (P-1). This participant maintains:

I didn’t have that many undergraduate statistics classes; it wasn’t a big thing at that time. But, in my graduate program, I guess I was kind of disappointed that I didn’t have much math and so we were given the option, we had to take a certain number of credits to qualify for the degree and the comprehensive exam and I chose to add on a cognate in research and measurement. And I really enjoyed those classes because it made me look at a lot of different things. It made me not just look at statistics, but at analyzing, you know, test items and because those are the things that you can take things and statistically say that that these are good questions and these are bad questions and this is a good test. And it was kind of combined together and I really enjoyed those classes. To be able look at the statistics we did some programming, we did some analyzing data. It was just a good thing to do because I got to look at it in terms of education above and beyond what I had in my masters program and I was able to see how test scores that were reported and when I was teaching public school it allowed me to see how the test reporting worked. (P-1)

During the course of discussing the coursework that enveloped P-1’s experiences and perceptions, there is again a focus on analyzing and making sense of standardized test scores. This is congruent with much of the discussion held with P-1; namely that a knowledge of statistics is fundamental for meaningful interpretation of standardized test data.

P-2 also did not have any coursework in statistics as an undergraduate student. Rather, this participant, approximately halfway through her public school teaching tenure in the 1990’s, went through numerous summer sessions spanning multiple years in what was known at the time as the Statistics Education through Quantitative Literacy program,
which exposed her to the wealth of academic richness that statistics and data analysis
topics can offer an oftentimes sterile mathematics curriculum. During the course of her
involvement in this program, this participant received graduate credit at the university
where the courses were taken and was eventually asked to be an instructor in the
program. *P-2* opined that her knowledge of statistics was drastically influenced by the
Statistics Education through Quantitative Literacy program.

> My education has totally shaped my perception…it has made me love statistics,
> first of all because I had thought of statistics as a very dry, boring math course
> even though I had never, actually in my doctoral degree I did take some high level
> statistics courses, but prior to that I really had no interest and when I took those
> workshops in the summer at the university, that just totally changed my
> perception because it was all about gathering data and representing and analyzing
> data and it was a lot of fun. We engaged doing statistics. (*P-2*)

During the course of conversation, and from the data collected from the participants prior
to interviews, it was evident that *P-2* does not have coursework in calculus-based
statistics, for which this participant makes no excuses. This participant is of the opinion
that her love and fervor for statistics is fleshed out of her interactions with great statistics
education instruction through the Statistics Education through Quantitative Literacy
program, which ultimately encouraged program participants to authentically engage
students with meaningful data to personalize and provide meaning for learning.

*P-3* had numerous undergraduate mathematical statistics courses, which is unique
in relationship to the participants in this study. Similar to *P-2*, *P-3* was also involved in
the Statistics Education through Quantitative Literacy program. Also similar to *P-2’s*
experience, *P-3* upheld that this program was definitive in shaping her perceptions of
statistics education. She explains:
I would say that I probably have more statistics courses than most that went through an undergraduate mathematics degree because whenever we were allowed to elect content courses, I always chose statistics. I would probably say that we had one required statistics courses and then I probably took two more beyond that. And not only that, but some of my professional development which actually got me into my doctoral work was some workshops called statistics education through quantitative literacy back in the 1990s. So that was where the faculty at the instruction brought in in-service teachers and tried to get them to, again gain quantitative literacy and teach all sorts of topics through data analysis and gathering and things like that. I went there sort of as an in-service going through the program and then I was asked back to be a teaching assistant in the program. Those experiences really have really influenced me quite a bit, but it still hasn’t created this urgency to present my teacher candidates with a depth of statistical knowledge, maybe thinking that “If I was able to get professional development in my early years, then they can do the same.” (P-3)

During this course of addressing the coursework and experiences that shaped P-3’s perception of statistics topics in the K-8 math methods course, it is again evident that this participant feels as though actual topics in statistics are not necessarily relevant to the K-8 math methods course. As this participant presents throughout her discussion (e.g. page 121), a math methods class holds many expectations for teacher candidate learning outcomes. She states, “It’s a zero sum game…To add something you have to remove another and that’s the challenge” (P-3). It is also interesting to consider that this participant regards professional growth as a function of personal industriousness, alluding to the fact that teachers could seek out professional development opportunities much like P-3 did as a blossoming grades 7-12 mathematics teacher. Again, much of P-3’s comments and perceptions are directed at the purpose of the math methods class to expose K-8 teacher candidates to a wider spectrum of global classroom practices of assessment, differentiation, and teaching methods as opposed to specific pedagogical practices around a specific area of K-8 curriculum.
Question 7 exposed that each participant’s education, both through specific coursework and professional development initiatives, has influenced their perceptions of statistics as a K-8 math methods teacher. P-2 and P-3 strongly indicated that the Statistics Education through Quantitative Literacy program was a defining factor in their perceptions and knowledge of statistics education. Also, P-1 indicated that having the coursework experience in research and measurement provided a strong foundation for forming perceptions related to statistics, with particular emphasis on high stakes, standardized testing.

**Question 8: What coursework is essential for preservice K-8 teacher candidates to have in order to understand statistical concepts in a K-8 methods course?**

Question 8 elicits one primary perspective from the participants with respect to the necessary coursework for preservice K-8 teacher candidates. These responses appeared to stem initially from the mathematics coursework required at the participant’s particular institutions of higher education for admission into the teacher preparation program. The overarching Key Point from this question is:

(A) Preservice K-8 math methods students are unprepared to adequately address statistics topics in the methods class, while also indicating a need for a conceptual foundation of statistical ideas.
Key Point A: Preservice K-8 math methods students are unprepared to adequately address statistics topics in the methods class, while also indicating a need for a conceptual foundation of statistical ideas.

One participant, P-2, draws upon the need for a conceptual (as opposed to a solely theoretical) foundation in statistics for preservice K-8 teacher candidates to be well prepared for the challenges of the classroom.

To me it’s more about a deeper understanding of introductory statistics rather than advanced statistics because I think that many, many people can pass an introductory course with an A, but they don’t understand those concepts and what underlies those concepts and to me that’s what teachers need to really understand to make it relevant and for good instruction for their students. (P-2)

P-2 also speaks to the need for statistics instruction that is founded in the constructs of constructivism in order to advance statistics content through pedagogically sound mediums.

There are exceptions in the math department here who have embraced mathematics education and a constructivist view of teaching and even though they are mathematicians, they teach in a way that a math educator would teach. The majority of mathematicians don’t… I think there are probably tons of math educators out there who are also very traditional in the way they teach and I think a lot has to depend on your background, your own philosophy, where you got your degree, and what you’ve been exposed to and also the people you work with. So, just because someone is a math educator doesn’t mean that they can teach well either. (P-2)

As P-2 indicates, there are mathematicians who have adopted a strong philosophy of teaching content through a conceptual model in teacher preparation content courses and there are math educators who, on the whole, endorse very traditional, algorithmic ways of teaching mathematics. To this participant, the most salient instruction for statistics education is one where preservice teacher candidates are exposed to an illustrative
method of learning statistical notions so that they are versed with the dispositions of teaching statistical concepts rather than remote statistical computations, with the end goal of transforming the images of what and how statistics should be taught.

P-2 continues by sharing the content courses utilized at her institution and also addresses the students’ level of preparation:

We actually offer, and it’s now a requirement for our middle-level students who are grades 4-8 certified, probability and statistics for elementary and middle level teachers and it’s a 3 credit course. But I don’t think it’s enough, but we’re lucky that we even have that. To me, that’s a minimum. I mean our students…they get in one of their first content courses a little bit of statistics, like half of a semester, and then they get the 3 credit course purely in probability and statistics. But it doesn’t go up through hypothesis testing and there’s just not enough time because we integrate and use technology and we integrate the content and pedagogy. So they would more than that even, to be very well prepared. (P-2)

While P-2 communicates concerns related to content exposure for K-8 preservice teacher candidates, P-1 and P-3 extend a much more minimalistic treatment of statistical concepts at their respective institutions. P-3 explains:

Our teacher candidates have two courses, so 6 credits for the math, that is required prior to taking the methods class and if you take those six course hours and divide it by the five content areas that NCTM puts out for K-12, I would say that that would be a fair amount of preparation…But they would probably need a three-credit course in statistics taught really well on a conceptual level as opposed to a procedural level by someone in the math department who teaches statistics for research and things like that. So they would need someone who is very student-friendly and who was very project-based, you know, to get the teacher candidates to sort of internalize the concepts in statistics. And they would need more than that, to be honest, I believe. But we know it’s not going to happen. It’s just the number of hours that are required by the state department in all of the other areas like English language learners, special education, technology, and all that stuff. There are just not enough hours to prepare teacher candidates for the typical teacher candidate to come into my class with a depth of knowledge of statistics. (P-3)
It is interesting that while P-2 initially states that two classes divided among the five NCTM content areas would be a sufficient knowledge basis for the preservice K-8 teachers, she then goes on to state that at least one course dedicated to a conceptual approach to statistics would be most ideal. P-1 similarly resounds:

Students have two take two mathematics classes to in order to take the methods course. The first class involves problem solving and whole number operations. The second class covers rational numbers, ratios and proportions, data, statistics, and probability. The issue is that their background in those areas, especially in statistics, is so weak that you can’t begin to cover as much material as you need to cover with them and I realized that I guess last spring because I had two teach two of these [content] classes and I had some students in there who had statistics in high school who understood all the stuff and I had other students that obviously had not had anything that had even came close and so it was really kind of a struggle to get through it and I kind of felt like I had to weed things down because I only saw them two days a week…Quite honestly I was looking at another teacher certification program in another state and that state has a Pre-K to 6 teaching certificate and I was looking at their programs they had to take 27 credits of STEM. And the class list included a class called statistics and calculus I and I thought “I could live with that.” I think that would good because if they are high school graduates they should have had all of the content and understand how and why place value works, and all these other concepts that we hit on in our content courses here. Shouldn’t we expect them to be able to do college level mathematics even if they are going to be elementary school teachers? So I would like to see us strengthen. I am tired of, I am getting on my soap box I guess, I am tired of teaching to the minimum! Why can’t we produce a better quality teacher with higher expectations to get them through the program and better content and understanding and knowledge? (P-1)

Clearly P-1 indicates a strong level of frustration with respect to the types of content addressed in the prerequisite courses for the math methods classes. In fact, she speaks quite intimately because of a history of instructing the teacher preparation mathematics content courses and knowing all too well just how inadequately the content of the classes serves in preparing K-8 methods students for the content necessary for success in a standards-based educational milieu and also lead to a successful launching point into the
classroom. She strongly feels that preservice K-8 teacher candidates need to be exposed to college level mathematics with a greater focus on developing significant ideas as opposed to re-teaching elementary mathematics concepts that all high school graduates are expected to master. To this end, *P-I* feels that the prevailing method of the teacher certification program at this institution is inhibiting because of diminishing standards.

> We have students who get D’s in both of those [content] classes and they are still allowed in the teacher education program. And they are still allowed to get certified. Who in the world would hire somebody to gets a D in math for elementary teachers?…It’s very irritating that we don’t have higher math standards and I really think that they need to know more than a first grader or more than a second grader. (*P-I*)

Question 8 reveals that the participants believe most preservice K-8 teacher candidates are conceptually unprepared with a strong understanding of fundamental statistical ideas. Two participants (*P-2 and P-3*) specifically indicate the need for a stand-alone course in statistics that is taught by someone who emphasizes the deep-seated meanings of the statistical topics discussed in class. This is echoed in a similar sense by *P-I* who maintains that much of the preparatory content coursework that the preservice K-8 teacher candidates are exposed to is far too basic for high school graduates and calls for a more rigorous survey of mathematical topics that empower the future teacher to explore significant mathematical and statistical ideas, suitable for post-secondary students.
Question 9: How would you generally summarize your experiences as K-8 mathematics methods professor around concepts related to statistics? Is there anything else you would like to include or state?

The last question that was posed to the K-8 math teacher educators who participated in the study was quite open-ended. This particular question provided the participants a chance to speak to their general experiences, and even perhaps address some experience or perception that they may not have had the chance to address in the interview up to that particular point in time. The Key Point that evolved from the data related to the idea that:

(A) Statistics education is an emerging area of K-8 instruction in the mathematics methods course for preservice teachers.

Key Point A: Statistics education is an emerging area of K-8 instruction in the mathematics methods course for preservice teachers

One participant, P-3, spoke to the opportunity that statistics topics might offer a methods class in the future, and was reflective about her current practice.

I believe that with every content area in my methods class that in order to maximize the results and time that we have that we embed statistics within other topics… pedagogy topics in my methods class. It [statistics] is addressed but probably not made explicit. (P-3)

She goes on to say:

[Statistics] might be a missed opportunity in the K-8 curriculum; that is that we know that students, K-8 learners don’t want to be passive. And we know that the being passive and learning math is not ideal, so I believe that collecting
data…something about something that is relative to the learner would be an awesome way to address other mathematical topics such as number sense, the operations, and so on. So I don’t believe that statistics would be detrimental…it would be a great way to integrate other topics into the ideas of statistics and the concept of statistics. But, what kind of work that K-8 teacher have to do to match all the standards and to find the activities and the tasks that would have a statistics theme but also address the other content areas that are required…so it’s a challenge for sure but it certainly would be worth…I don’t think it would get in the way of anything. (P-3)

Again, P-3 shows a high degree of fidelity to the matter and issue of time when discussing and summarizing her experiences with statistics topics in the K-8 methods class. It can also be observed that this participant discusses the possibilities of statistics in terms of student engagement and indicates towards the end of the discussion that “I don’t think it would get in the way of anything” as if to strongly imply that statistics education is a secondary consideration or afterthought in the K-8 curriculum, only to be covered after other, more significant areas of mathematics are developed.

P-1 spoke to the importance of statistics in preservice teacher education and discussed a class that she collaborated on with the mathematics department.

I think that there is some growing understanding and interest. I would say understanding that statistics is an important area that more people, regardless of their major, need to study. Last year I talked to the math department and I said “Why don’t have a statistics class for PE teachers? They have to do statistics. They are all about, you know, improving body skills and that kind of thing. Wouldn’t it be neat if you had a statistics class that could help them and integrate that into PE or integrate it into something else and help them to read standardized test scores? I mean, would that be worthwhile?” They did start a separate statistics class for education majors who are not necessarily looking for elementary certification. I don’t know if it is still going on this year, but they did try it last fall. But I think those kind of things would be good. I would rather see us require statistics rather than math as a liberal art. I mean math as a liberal art, depending on who teaches it, I’ve had some students who have told me that they have gotten a lot out of it but it depends who taught it because there is not one required content or stand that you have to teach for that class, it’s whatever the
person who is teaching it decides they want it to be. I think that a statistics class would be valuable to everybody, not just education people.  \((P-1)\)

\(P-1\) went on to summarize her experiences and perceptions by stating:

I try to balance everything out because there are things that are important. I try to make sure that students see that while it may just be arithmetic, it’s really the beginning of algebraic thinking. It might just be arithmetic, but it’s really part of geometry. And I try to do that with statistics as well. I try to make the connections to see that, you know, this is something you might teach in third grade, but what happens in third grade? I don’t think they see the whole picture. I think every teacher needs to know more than what they have to teach and more than what their students know. So, the other issue is time. It just would be very, very helpful if the students had more content background in some of these areas such as statistics before they get to a methods class. I would love to see them have to take more math classes before they get into a methods class. The material [preservice teacher candidates are expected to know] only goes through eighth grade, which is Praxis I. I just would like to see that change but who knows. I have some major concerns because when I look at the new classes that are coming online in the fall for Pre-K-4 methods class with special education dual majors in there, they have to be prepared to teach through eighth grade and the Common Core Standards say that even if the students are special education, they still have to cover the same content that a student in a regular classroom would cover. So where are they going to get this background? I think it has created a big mess to divide these teaching certificates up like this and I know there are people in my department who think well “they are only going to teach K-4 and you don’t have to go beyond certain topics.” I am sorry, you do. Teachers need to know where their kids are going and what they need to learn after they leave their classroom. \((P-1)\)

She has exposed a lack of content knowledge on the part of the student throughout discussions related to statistics in the K-8 math methods class. To this end, \(P-1\) has also surfaced concerns about the content preparation of incoming K-8 math methods students, which she contributes much of this problem to. She strongly believes that the ever-growing high-stakes testing movement will ultimately push teacher candidates to know more and do more, and this growing expectation is not being sufficiently met with the content knowledge that they receive in aggregate within the teacher preparation program.
Finally, P-2 summarizes her experiences and perceptions related to statistics and teaching K-8 math methods for preservice teachers. She concludes:

I enjoy working with the preservice teachers, especially the elementary level, because they are very willing to admit that they don’t know or understand particular things and they know that they are going to be responsible for teaching it. So they are very willing to do whatever I ask them to do. They get frustrated with topics like statistics and I tell them that’s good because that’s what’s going to happen to their students in their classroom and that they should struggle while they are learning because you will learn it better. I think that using a more hands on approach, a constructivist approach, is successful for a lot of kids, for most kids, if their minds are open enough. Some of the worst students that I have had were secondary majors who changed to elementary who think they know that math and believe that I won’t teach them anything and they don’t understand pedagogically how important it is to understand statistical concepts in different ways conceptually, not procedurally. I don’t care if you can use the formulas or not. (P-2)

Here it can be observed that P-2 expresses much affection for the K-8 math methods students who are preparing to be teachers. She states that her experiences related to teaching statistical ideas to K-8 preservice teachers is largely rewarding because they openly express some of their struggles with understanding the relevant content, while also maintaining a relatively favorable disposition.

The final question of the interview reveals that the participants place regard in the importance and challenges facing them as K-8 math methods professors. P-1 has encouraged the mathematics department to offer an elective course in statistics, but feels as though many preservice teachers are largely unprepared, in a content knowledge sense, for the curricular challenges that wait. P-2 addresses the willingness of the K-8 math methods students to grapple with content concerns in her class related to statistics. Finally, P-3 states that while statistics may be “a missed opportunity” in his methods classes, there is potential merit for developing statistical ideas at this level.
Grand Tour of the Findings

It is evident that Chapter IV provides an in-depth exploration of the data; however, the corpus of the findings can prove to be overwhelming at times. Thus, at the potential expense of over generalizing, this particular section will, as its name suggests, provide a grand tour of the perceptions and experiences of the participants. This section will be organized according to the participant, relative to the principle points made during the course of the interview, while also making several comparisons.

P-1 approached the interview with a long history of teaching K-8 math methods courses. In the interview, she spoke about the importance of statistics in the K-8 curriculum as a function of the evolving nature of elementary and middle school mathematics curriculum. To this end, P-1 indicated that many junior high school and senior high school curricula are introducing ideas such as standard deviation and graphical displays at earlier times in the K-8 curriculum and statistics is no longer a topic that is left for graduate school or the hard sciences. P-1 described statistics as a subset of mathematics, stating that “Statistics is a branch off of mathematics. It’s an applied science.”

In terms of her role as a K-8 math methods professor, P-1 indicated that she is required to review elementary statistical content (mean, quartiles, box and whisker plots, etc.) in methods course because students entering the class oftentimes lack even procedural knowledge of statistical ideas. In fact, the notion of preservice teacher content knowledge of statistics struck a strong cord with P-1 and she spent a great deal of time
discussing the lack of preservice teacher preparation at her institution. Specifically, the lack of preservice teacher preparation was framed by P-I with respect to the coursework necessary for certification at her respective institution as minimalistic (in terms of depth and breadth) and largely unmonitored (according to P-I, the structural curriculum written for the content courses in mathematics for K-8 teacher preparation was not closely followed by the mathematicians teaching these courses).

In terms of curriculum, P-I utilizes in-class activities such as a Skittles project to demonstrate teaching practices utilizing inquiry and questioning strategies for the preservice teachers so that they may witness these events through the experience of a student and future teacher. She also utilizes written tests and quizzes to assess the preservice teachers’ knowledge of statistical content (e.g. construct a box and whisker plot from this data set) and pedagogy (e.g. how would you introduce the concept of standard deviation to a class of mixed ability sixth graders?). Moreover, P-I feels that preservice teachers must be responsible consumers of data, and having a strong knowledge of statistics will promote the future teacher’s ability to interpret and convey findings from high stakes testing data. To this end, P-I holds that understanding test data will inform more effective curricular decision making, which she related directly to her discussion of statistics within the K-8 methods curriculum.

P-2 maintained the longest tenure of K-12 teaching experiences of the participants, with nearly 30 years. During this time, she was actively involved with the Statistics Education through Quantitative Literacy program, a professional development initiative (with the opportunity for graduate credit through the hosting university) to
expose in-service teachers to rich, hands-on learning experiences that they could take directly back to their classrooms. Up until the time $P-2$ was exposed to the Statistics Education through Quantitative Literacy program, she was largely unfamiliar with statistics education initiatives, and she candidly maintained that “it made me love statistics.”

In terms of her teaching practice, $P-2$ referenced the Guidelines for Assessment and Instruction for Statistics Education (GAISE) (Franklin, et al, 2007), stating that preservice teachers themselves must be actively involved in the learning process in order to be effective teachers that encourage and foster their future students’ statistical growth. To this end, she describes statistics as being “numbers in context,” whereas mathematics “looks at the structure of numbers and variables.” $P-2$ utilized learning activities to assess the preservice teachers’ knowledge of statistics content, but more particularly pedagogy, with the most noteworthy activity being a research project. This particular research project challenged preservice teachers to pose a question, collect the data, analyze the data, and interpret the data, according to the GAISE framework that she endorses.

$P-2$ works solely out of the mathematics department, where the K-8 math methods course was offered, and described a close relationship with the content experts in her department. She discussed a more effective level of student content knowledge that $P-1$ and $P-3$, and contributed this to the fact that she instructs the methods class in the same department as where the prerequisite content courses are offered. To this end, $P-2$ felt as though there was a sense of departmental unity and cohesion that was enacted
through the curriculum sequence of K-8 mathematics teacher preparation courses at her particular institution.

*P-3* was able to claim the most mathematical statistics coursework as an undergraduate, with a total of three (3) courses. She spoke fondly of statistics, especially in a preliminary discussion prior to the interview, indicating that she truly enjoyed teaching statistics at her high school, before she earned her terminal degree and took this position in higher education. Like *P-2*, she was involved in the Statistics Education through Quantitative Literacy program for several years while she was a high school mathematics teacher. *P-3*’s university teaching experience was based solely in teacher preparation, so she has had many sections of methods courses during her tenure as a university faculty member.

In *P-3*’s assessment, different from *P-1* and *P-2*, the K-8 math methods class should be intended to “get students (preservice teachers) to change their view of how math can be taught” and that it is “more important to give the students (preservice teachers) a general, solid philosophy of teaching mathematics and not as much specific instruction on specific content areas.” Through this lens, she is of the opinion that her role as a math methods professor is one of demonstrating sounds teaching strategies, not necessarily presenting a comprehensive overview of the mathematics and statistics curriculum that the preservice teachers may be expected to teach. Yet, *P-3* did contend that she felt as though math methods students are often ill-prepared for teaching statistics in the K-8 classroom, stating that the mathematics content courses at her institution meant
to prepare students for instructing elementary and middle school curriculum contain “…maybe a class period dedicated to statistics.”

*P*-3’s representation of statistical ideas is limited in terms of assessment, reflecting her fidelity of establishing a corpus of general pedagogical best practices among the preservice teachers. While she discussed a probability activity that she utilized from the textbook several semesters ago, *P*-3 feels as though there are perhaps larger lessons for the preservice teachers to learn in the methods class, such as lesson planning, questioning strategies, assessment, and differentiation. In sum, *P*-3 acknowledged that statistics is an often a “missed opportunity” in the K-8 curriculum, but felt strongly that she had greater ends to achieve in the math methods course than presenting statistical content or particular teaching strategies particular to statistics.

**Summary**

According to the interview protocol, this chapter has methodically addressed each question posed to the participants, followed by the major Key Points that occurred in the subsequent discussion related to each question. In this way, the participants’ voices are captured and represented related to each specific question. These Key Points embody the lived experiences and perceptions of the participants in each of their individual roles of instructor in the teacher preparatory class, K-8 mathematics methods.

The next and final chapter will serve several purposes. First, a discussion of the major trends from Chapter IV will seek to collate the Key Points related to individual
questions. Next, the limitations of the study will be discussed. Finally, there will be a discussion related to the implications of the study while proposing possible avenues for future research.
CHAPTER V
CONCLUSIONS AND IMPLICATIONS

This chapter will serve three (3) distinct purposes. First, there will be a reflection on the major areas revealed in Chapter IV. Next, the limitations of the study will be identified. The chapter will be concluded by making recommendations for further research in the initial area of the study, while also making extensions into related fields of scholarship.

Reflections on Major Findings

The purpose of the research was to establish the experiences related to and perceptions of statistics, held by preservice mathematics teacher educators. In particular, the guiding questions of the research were:

1. What are the experiences of preservice mathematics teacher educators related to statistics?
2. What are the perceptions of preservice mathematics teacher educators related to conveying statistical notions in the K-8 math methods class?

The findings from this study provide an intimate indication of the experiences and perceptions of K-8 mathematics methods professors related to statistics. The amalgam of Key Points represented in Chapter IV reveal that K-8 math methods professors channeled their discussion in three (3) unique, but not necessarily distinct categories or domains that
provide a substantial foothold for understanding their experiences and perceptions related to statistics in the role as a K-8 math methods professor. The three (3) domains are:

(A) Preservice teacher preparation,

(B) Conceptualizing the role of statistics, and

(C) Allocation of time.

These domains will be discussed through various data strands from the participant interviews. There will also be areas of discussion within this section through a lens of researcher reflection.

Preservice Teacher Preparation

Each of the three participants discussed the notion of preservice teacher preparation in statistics during the course of her interview. Particularly, the corpus of data demonstrates that a resounding area of concern advanced by these professors resided in a lack of student experience and fluency in topics related to statistics. To this end, there were large variations that were reported related to students’ exposure to statistics prior to entering the methods course. P-3 reported that students receive “the equivalent of a class period dedicated to statistics,” whereas P-2 held that students entered her methods class with a sound procedural knowledge, but the students fell short in the ability to articulate a clear understanding of the meaning behind the ideas, which can most likely be described as a lack of understanding.

To varying levels according to their personal dispositions, the participants agreed that some knowledge of statistics is required for preservice teachers entering the math
methods course. While \( P-2 \) spoke matter-of-factly to a definitive statistics and data analysis core that students entering the methods course were required to complete, \( P-3 \) addresses that very little statistical and data analysis topics are covered as requisite understandings for enrollment into the methods class. Finally, \( P-1 \) stated that there were course objectives in one of the mathematics classes leading up to the methods course that addressed statistics and data analysis topics, but experience has led this participant to perceive that there is not a high degree of fidelity in meeting this curricula with sound instruction from the mathematics department. Subsequently, \( P-1 \) has felt the need to re-introduce some of the basic statistics and data analysis topics to the math methods students, at the risk of not addressing or skimming over other course objectives.

Many of the indications that surround student success in a mathematics methods course reside in his or her experiences in coursework to that point in time. As \( P-1 \) and \( P-3 \) particularly discussed, students are, more often than not, underprepared in all realms of relevant K-8 mathematical and statistical content. A portion of this disparity obviously lies in the fact that students engage in different academic tracks in their secondary careers and some students are much more exposed to significant mathematics than others.

Yet, the data revealed a strong claim that the university coursework requisite for admission into the math methods class is insufficient. \( P-1 \) and \( P-2 \) both teach or have previously taught the prerequisite mathematics content classes leading up to the methods class (these courses vary in name, but provide a content overview of numbers and operations, measurement, geometry, algebra, and data analysis and probability) and \( P-1 \) plainly expressed that the curriculum of the required content in the preparatory courses is
largely professor-determined and almost always ill-suited for the conceptually-based content demands of reform-based school mathematics curricula, particularly in statistics.

Part of the challenge facing the culture of curriculum mapping and alignment may exist between colleges and departments. While the math methods classes at P-1’s and P-3’s institutions were taught out of the college of education, P-2 articulated that the methods class at her institution was taught out of the mathematics department. P-2 spoke much more positively about student content knowledge than P-1 and P-3, and noted that the math educators and mathematicians at her institution have relatively good relationships and are respectful of one another. On the other hand, P-1’s role of occasionally teaching out of the mathematics department has not opened widespread lines of communication, although she mentioned that some mathematicians are receptive to ideas. Thus, potential matters of communication, power, authority, and final say stand a reasonable chance of clouding curriculum realignment to meet the challenges of present-day reform in topics related to statistics. Aside from all bureaucratic matters, some stakeholders teaching prerequisite mathematics classes may not be fully aware of the significance of certain reform topics such as statistics, while also lacking themselves with the knowledge of conveying these relevant ideas through a conceptual lens.

Also, statistics was a term used rather loosely by the participants. For instance, P-2 spoke specifically about GAISE (Franklin et al, 2007) and the tenets of statistics reform, whereas P-3 referred to “mean, median, mode, and range” synonymously with all matters related to K-8 statistics content. P-1 spoke often about the notion of preservice teachers’ understandings in her descriptions of statistics in K-8 methods class, and was
very interested in challenging her students’ knowledge of interpreting data both on the teaching and high-stakes testing platforms. Yet, the idea of teaching preservice teachers for the sake of interpreting test score data assists the future teachers in ways that are starkly different that crafting within them a statistical knowledge for teaching. Participants’ educations will be discussed at greater depth later in the chapter, but it is apropos to state that while math methods professors typically hold an advanced, if not terminal degree, based upon university credentialing and accreditation requirements, any one particular area of school mathematics topics (e.g. statistics) may not reside within the scope of a professor’s greatest area of content knowledge. Thus, there is sometimes a bit of posturing that occurs between professionals of the same general discipline (e.g. mathematics education), and findings with such varied responses points in the direction of a need for more deliberate discussions between mathematics educators related to the form and structure of evoking, in this case, statistical reform. In fact, much conversation exists around ideas like hands-on, minds-on learning, student engagement, and authentic learning platforms within and among the professional vernacular related to statistics education (e.g. Chance, 2002 and Shaughnessy, 2007), but perhaps the data suggests that we introduce the elephant in the room – What does good instruction around the ideas of statistics look like? How do I need to understand statistics for my preservice methods students? How can I foster their knowledge of content and pedagogy in my methods class?

An additional matter relevant to the discussion of the challenge of student preparation in mathematics and statistics content lies in the crux of enacted curriculum
and accountability. At the risk of over generalizing, it is relevant to convey that tertiary curriculum and K-12 curriculum are often conceived of differently in terms of professor/instructor expectations for the coverage of particular content and a degree of professional autonomy (sometimes referred to as artistic license). Particularly, K-12 teachers usually have a rather prescribed sequence of topics to cover in a class whereas many professors in higher education enjoy the liberties of academic freedom, where a course catalog provides a glancing sentence or two about the major topics that may be covered in the course. As P-1 and P-2 adamantly discussed, outcomes and objectives vary between mathematics professors in preparatory content courses for preservice teachers. Frankly, they expressed that some mathematicians that are assigned to teach math content classes for K-8 preservice teachers regard the experience a lot more like a babysitting chore than a professional responsibility and the outcome of their lack of enthusiasm for the material quickly shows up in the students’ weak knowledge of the content.

As this study has demonstrated, the analysis of the data has exposed numerous issues related to preservice teacher preparation. In particular, there have been ideas advanced regarding the content preparation of preservice teachers, challenges related to adequate content coverage of statistical ideas in preparatory mathematics content classes, and capturing an overarching perspective of the most fertile means of presenting statistics in the methods course.
Conceptualizing the Role of Statistics

Conceptualizing the role of statistics in the K-8 mathematics methods course for preservice teachers lies at the heart of this study. Experience informs perception and perception strongly contributes to the enactment of values-based decisions in matters such as curriculum design for a methods course. As previously discussed, there is a strong amount of liberty afforded to full-time faculty at colleges and universities to utilize their professional authority in making curricular decisions and the analysis of the data has shown that this authority has perhaps compromised the presence of statistics in the K-8 math methods courses for preservice teachers.

This study revealed that there were numerous layers that contributed to the perceptions of statistical topics within the math methods course. To recall, P-1 discussed in her interviews the importance of continually revisiting content topics within the scope of presenting relevant teaching demonstrations, led by both the instructor and preservice teachers (e.g. p. 87). P-2 championed continuous content discussion in her methods class also, and she opined that methods students need to see topics like statistics as if they were K-8 learners – collecting, summarizing, and analyzing data. P-3 held that “In my methods class, I believe it’s more important to give the students a general, solid philosophy of teaching mathematics and not as much specific instruction on specific content areas.”

Obviously, there are common features among each of the three participants relevant to their modes of instruction and considerate of the values they hold. For example, each participant strongly values good instructional modeling in the math
methods course. Yet, the way that this is accomplished looks significantly different. In the case of P-1’s methods class, content guides the order and sequence of her class, giving students an opportunity to re-familiarize themselves with topics, while observing the content taught in a way congruent with student knowledge formation. P-2 takes a hands-on, minds-on approach to the methods class, like P-1, guided by relevant content topics, for students to re-engage with old material that is demonstrated through a constructivist lens. P-3 takes a much more direct role in the methods class, where she reviews the proper lesson planning structure, assessment, anticipatory sets, differentiation, and teaching strategies. With respect to teaching strategies, P-3 demonstrates different methods of teaching such as direct instruction, problem-based teaching, and the like, where she described that the “what” of content is not as significant as the “how” of pedagogy in her course. It is equally important to P-3 that her preservice teachers are aware of the multiple ways mathematics can be taught, so that the preservice teachers are capable of devising a teaching approach that is suitable to their disposition and personal strengths.

Experience and perception plays a large role in such conceptualizing the role of the methods class and within that course, the place where statistics may or may not inhabit. P-1 and P-2 structure the entire scope of the methods course around content, and providing students with experiences of seeing content in new ways and presented in new manners defines their motives. P-3 envisions a more expansive role of the method course, exposing students to different ways one can teach mathematics, and many other important roles of the teacher. When experience is threaded into the discussion, one may
inquire about the differences that exist in structure and design of the K-8 math methods course, as well as the role statistics plays.

To this end and as the data exposed in Chapter IV, P-2 and P-3 were both involved in a professional development initiative spanning several summers called Statistics Education through Quantitative Literacy. The data also revealed that both participants felt as though this initiative strongly enhanced their perception and fondness of statistics. So why does P-2 actively address statistics in her methods course while P-3 does not? Well, it’s certainly not because one taught statistics as a high school teacher and the other did not, because they have both taught statistics. For that matter, there is no other reason that can be disaggregated from the data that points directly to a cause and effect conclusion related to a “turning point of statistics education orientation.” Perhaps the most prolific conclusion that can be drawn is that this study has revealed that the math methods course is conceptualized differently between professors with strikingly similar backgrounds not necessarily because one values statistics more than the other, but because the role of the methods course is fundamentally perceived in a different light. To this end, there appears to be a strong indication of the fact that while a math methods course (or something close to it) is in the course catalogue of entirely all teacher preparatory programs, the direction and outcomes of the course in particular may vary widely among different professors. As P-3 pointed out in a parting comment that took place aside from the interview platform, math methods is not nearly as straight forward as the calculus I curriculum of limits, derivatives, and an introduction to integration.
Consequently, the structure, design, and conceptualization of the methods course, framed within the concept of time, will be discussed in the next section of this chapter.

This study reveals that there is an emerging need to unearth the enacted outcomes of K-8 math methods classes, and teacher preparation programs in general, so that matters such as the role of statistics has a well-defined place in the teacher preparation sequence. Otherwise, there will be a significant opportunities to overlook salient matters in the preparation of future teachers. While there have been decade-long debates around ideas of traditionalism versus reform-based learning in K-12 mathematics (e.g. Brownell, 1947/2004; Erlwanger, 1973; Heid, 1988), there appears to be a strong undertone of a similar nature in higher education related to teacher preparation programs in mathematics education (e.g. Ball, Lubienski & Mewborn, 2001).

The participants involved in this study discussed the nature of statistics in their methods class and provided a rationale for its presence or absence in the class’s curriculum. While each participant has, in their own right, a fairly developed background in statistics topics (ranging from scientific traditions to descriptive, educational manifestations), the data reveals the participants struggle with conceptualizing certain aspects of statistical topics in the K-8 math methods course. To this end, P-1 stated “You know, sometimes I don’t really know” when asked about the big ideas related to statistics in the methods class and P-3 held that “I don’t think I could give you a good explanation between the two” when asked to discuss any differences she makes when conceiving of mathematics and statistics. Just as the mathematics education field has observed with the task of conceptualizing a vision of best practices related to teaching mathematics, this
study also reveals that mathematics educators presently struggle with speaking to the particulars of an emerging field of school mathematics topics, statistics. There must be an acknowledgement that as the field of statistics education reaches a point of increasing immediacy in the world’s culture and economy of data and chance, mathematics educators must foster new in-roads to developing a framework for statistics education that is meshed with a high degree of commitment to advancing teaching and learning.

**Allocation of Time**

The third and final significant matter uncovered in this study is surrounded by the issue of time. Time, in this case and with respect to this study, refers to the challenge that each participant described when attempting to meet the multitude of needs, skills, and experiences of K-8 math methods students required in a short amount of time. In fact, P-1 and P-3 were very precise when stating that they each had 37 contact hours with students in the K-8 methods class, an amount that they felt was extremely challenging in advancing student knowledge to position them for success as a future K-8 mathematics teacher.

Each participant discussed the primary challenge facing them as a function of attempting to foster the significance of a strong knowledge of content as a classroom teacher along with framing learning events for the K-8 learners to grow and expand their mathematical knowledge. Again, each participant specifically stated that another large challenge that piggybacks the issue of time allocation is the humbling fact that many students entering teacher education programs have had limited experiences with
pedagogically sound mathematics teaching. Therefore, changing the way math methods students conceive mathematics and statistics teaching and learning is a task at the forefront of the math methods class, which was discussed at length by P-3. Accordingly, P-3 spent much time discussing her rationale of the methods class that heralds the actual methods of teaching mathematics, with the use of content only discussed in terms of the actual methods. To her, content will follow; the purpose of the methods class is a foremost commitment to advancing mathematical teaching practice, while giving the methods students the opportunity to experience multiple modalities of teaching mathematics.

P-1 and P-2 were much more deliberate in the content aspect of the methods class, and statistics played a significant role in their discussion of the constructs of the methods class. While still acknowledging that time was a major challenging facing the planning and preparation of the course, they strictly adhered to a strong commitment to primarily advancing teaching methods through the lens of constructivism. Matters such as lesson plans and assessment were secondary to using the time in the classroom as a launching point to advancing the methods students’ knowledge of the marriage between significant content and teaching practice focused on student understanding.

The structuring of the methods course provides some platform for discussion also. Despite the fact that each participant resides in the same state system of higher education, the course structure of P-1 and P-3’s institutions seemed to position the methods class as a standalone course held in the college of education, whereas P-2’s institution appeared to make a conscientious marriage of the preservice K-8 content and methods courses as
stepwise and purposeful. While this study was not intended to shed light on the
departmental positioning of mathematics educators, P-1 and P-3 made clear a strong lack
of communication related to the methods course between mathematicians and
mathematics educators because of a separation, occurring both physically and collegially.
This communication between mathematicians and mathematics educators, according to
P-2, was highly beneficial in enhancing the efficiency and impact of the K-8 math
methods class. Having the physical and interpersonal closeness of mathematicians and
mathematics educators was discussed by P-2 as strongly influential in her growth as an
effective K-8 math methods professor.

Clearly, the allocation of time respectful to the coverage of statistical concepts in
the K-8 methods class was a reoccurring trend in the data. It stands to reason that a
discussion related to the appropriate coverage of relevant ideas related to the mathematics
classroom is an area of grave concern. This study has brought to light the fact that K-8
math methods professors involved in this study feel a great deal of pressure and
responsibility in allocating the time necessary to foster future success in their preservice
teachers. It is critically important, as these professors detailed, that there is an accessible
stage for professors of mathematics content courses and professors of mathematics
methods classes to discuss best practices for the most effective use of time to ensure
efficiency while reducing superfluity in the teacher education curriculum framework.
Limitations

This particular study is limited with respect to notions of design, scope, and implementation. In terms of limitations related to design (and in some respects the lens of phenomenology) matters such as redundancy and saturation remain unclear because of a small sample of participants (Moustakas, 1994).

An understood tradeoff of the phenomenological tradition is a lack of reproducibility in an effort to gain insight into the unique and individual experiences of each of the participants (Patton, 2001). Furthermore, since the experiences and perceptions of K-8 math methods professors related to statistics is devoid in the current literature, a particularly small sample of three (3) participants was preferable in order to position this study, and others in the future, in such a way that sheds light into a new realm of research. Yet, it must be acknowledged that data saturation does not exist in this type of study design. To this end, participants’ perceptions and experiences of statistics as a K-8 math methods professor were exposed to a multitude of uncontrolled variables, such as amount of K-12 teaching experience, certification credentials of the state where her teaching license was/is held, statistics coursework exposure, doctoral coursework in mathematics education, professional development opportunities and memberships, awareness of statistics reform documents, experience teaching other university courses, experience as a tertiary instructor, among others.

Another limitation that deserves considerable treatment is the somewhat nebulous notion of mathematics educator. Within the state system of education studied by the
researcher and assuredly others, the researcher has directly observed that there are K-8 mathematics methods professors who do not have a terminal degree, have no substantial coursework background in mathematics or mathematics education, and have no prior K-12 teaching experience. There are also teacher education programs in this particular state system of higher education that do not hold NCATE (National Council for Accreditation of Teacher Education) endorsement, which may or may not speak to a higher standard of instructor credentialing, namely that of mathematics teacher educators. Furthermore, as the participant sample in this study demonstrates, all of the participants hold terminal degrees, yet the doctoral programs that they studied in had very different outcomes and intentions (e.g. P-1 studied in a research-intensive program whereas P-3 completed a more generalized, practitioner degree). In sum, while a homogeneous sample was selected in regards to sharing the common experience of having taught a K-8 math methods course within the past two years, it is quite clear (revealed by Table 2) that the participants involved in this study have walked many miles in relatively distinct shoes to arrive at their current position as a K-8 math methods professor.

Gaining the support of potential participants proved to be a much more challenging task than originally planned, as well. Due to the fact that several of the K-8 math methods professors acknowledged the relative small sample and descriptive profile of the consenting participants, they felt as though their competency as a math educator may ultimately be up for interpretation in the hands of a department chair or other similar stakeholders. As it turned out, a large portion of prospective participants, from those who elected to participate to those who abruptly declined, were sensitive about being
identified in scholarly work among peers. One potential participant frankly indicated over the telephone that he/she was unwilling to participate because, regardless of pseudonyms and other unnamed identifiers, it would not take a tremendous amount of sleuth to boil his/her perceptions down to several individuals in the state system who are mathematics educators. Another prospective participant only agreed to participate if gender was left ambiguous which was accordingly obliged.

Pertaining to the interview protocol, it was somewhat unclear how prepared or unprepared the participants were to speak about their experiences and perceptions related to statistics on the very day of the interview. As P-3 stated, “I sort of had an idea because of the questions on the questionnaire that you would be talking about statistics and thought about it on the drive up here.” While the corpus of the data certainly evokes candid descriptions of the participants’ experiences and perceptions, a statement such as this certainly questions whether or not the participants “studied up” for the interview. Careful investigation of the demographic survey (Appendix B) may have signaled to the participants that there may be a discussion related to statistics education, even thought the actual study’s name or intentions were never divulged in advance. Yet again, it is necessary to state that the researcher was confident in the outwardly honest perceptions and experiences discussed by the participants during the data collection phase.

Another direct limitation of the data may exist in environment. One interview was interrupted by multiple phone calls in the participant’s office, which may or may not have contained information that may have influenced the outcome of the participant’s responses or subsequent attention span to thoroughly and thoughtfully consider the
breadth of the questions. Similarly, discussion around notions that may have been perceived as relating to her competency (particularly a lack of formal statistics education) noticeably made one of the participants uncomfortable and rather defensive, which may have influenced the direction and outcome of latter responses.

An additional limitation may have persisted in questions that assumed a particular outcome, such as holding a particular regard for statistics topics in the K-8 math methods course. As the data revealed, P-3 perceived the purpose of the K-8 math methods course to be much more foundational in terms of developing a philosophy for teaching mathematics, and not centered nearly as much on particular content strands. Thus, framing questions that directly address statistics seemed to inform the participant that statistics was important, whether they believed so or not. Similarly, with such an unexpected focus on statistics, participants may have been inclined to discuss hypothetical belief statements through popularized verbalization instead of directly focusing on their intimate experiences and perceptions. While this may or may not have necessarily been the case, participants might have been inclined to discuss a level of treatment respectful of statistical topics in their methods class that is incongruous with their practice. For example, a participant may have stated that he/she felt strongly about a particular area of statistics education because he/she was aware of the push towards statistics education reform in grades K-12, while not necessarily enacting such reform in the math methods class.

The research question protocol did make use of questions that did not necessarily solicit precise information, but the participants were very aware of their choice of words.
It was perceived by the researcher several times throughout the course of the semi-structured interviews that the participants would carefully craft their responses so that they would not create traps that they could not talk their way out of. For example, a casual mentioning of the Common Core State Standards (CCSS) quickly seemed to diverge into another arena, which may or may not have been influenced by this particular participant’s level of comfort discussing, in this case, the CCSS. To be precise as possible, there was an aura a few select times throughout the interviews where the researcher sensed that a participant wanted to add a topic for its namesake (e.g. CCSS) perhaps in order to bolster their perceived credibility, but did not choose to discuss it much further than to make mention of it.

Like all qualitative research that exists, limitations are present when the interpretation of the researcher is at the helm of the interpretative process. While peer member checking occurred with a colleague who is also seeking an advanced degree in mathematics education, Rich Busi, this cooperative process may still have not entirely honored the experiences and perceptions expressed by the participants. As Chapter III described the specific methods of the member checking process, utilized to produce the most robust rendering of the data, certainly fundamental limitations exist to the exacting interpretations of the participants’ lived experiences and perceptions.
Recommendations for Future Research

Although this particular study provides new contextual information related to the experiences and perceptions of K-8 mathematics teacher educators related to statistics, many areas of study may be derived from these results. Certainly to this point, the corpus of mathematics education literature is devoid of studies related to mathematics teacher educators and many matters related to teacher preparation in higher education. The following paragraphs will provide a descriptive outline of several such directions for future research.

One particular area that this study sheds light on is the variation that exists among mathematics teacher educators, including (but not limited to) their education, mathematics coursework, K-12 teaching experience(s), exposure to professional development initiatives, etc. Certainly mathematics teacher educators play a strong role in fostering the growth and perceptions of those they instruct and it would benefit the body of literature to determine their teaching experiences in K-12, content backgrounds, and doctoral programs to make future recommendations related to promising directions for mathematics teacher educator preparation. Related studies might ask: Should there be a minimum coursework content requirement (depth – complete the calculus sequence or breadth – at least 24 credit hours, for example) in mathematics and/or statistics? Should mathematicians instruct methods courses? Should mathematicians and mathematics educators teach math methods courses cooperatively? What dispositions do those who are considered (or consider themselves) mathematics educators hold relative to their
terminal degree program (e.g. Ph.D. in mathematics education, Ed.D. in curriculum and instruction, etc.) or undergraduate degree program (B.S. in mathematics, B.S.Ed. in grades 4-8 mathematics, etc.)? Several treatises found mainstream recognition at the turn of the century on this topic, such as the Conference Board of the Mathematical Sciences’ publication titled *One Field, Many Paths: U.S. Doctoral Programs in Mathematics Education* (2001a), yet there is an aura of ambiguity related to the title of mathematics educator and further research stands as the only beacon for direction and clarity.

Another interesting and beneficial area that this study brings to light is the notion of certification programs, both within and between states. As P-I pointed out, some states have very robust standards for K-8 and 4-8 certificates; whereas she believed the coursework and academic content expectations in mathematics held at her particular state institution were greatly insufficient. The body of mathematics education research would benefit from exploring different areas of certification programs, the expectations held for the attainment of such certifications, and the differences in the teaching-based outcomes that may persist between teachers trained through different programs. Perhaps such studies may provide ethos to a “common core” approach to mathematics teacher education programs, extending the tenets of reform documents such as the NCTM Standards (2000) and the GAISE (Franklin, et al., 2007).

A direct foil from this study resides in the representation of statistical content in math methods classes. While this particular study investigated the perceptions and experiences of K-8 math methods professors, follow-up studies naturally follow in the domains of the enactment and representations of statistical content in mathematics
methods courses. To this end, studies would profit from exploring the written curriculum used in accreditation-related documents and the enacted curriculum, particularly in statistics, to determine the fidelity of the teacher preparation programs. Similarly, the literature would benefit from the exploration of the influence of teacher preparation programs in mathematics and statistics with respect to particular preservice teachers and the written and enacted curriculum in their own classrooms.

Common to all participants in this study, there was a persisting trend related to the lack of content preparation of their K-8 math methods students. While studies have explored preservice and inservice teacher content knowledge (e.g. Ball, Lubienski, & Mewborn, 2001), this study has revealed that it is opportune to explore the representations of (statistical) content in the requisite mathematics and statistics classes for the math methods course. Particularly, the literature may benefit from not only the content addressed in requisite content courses in teacher preparation programs, but also how these courses are negotiated and taught by different stakeholders (i.e. mathematics educators, mathematicians, statisticians).

This study also provokes questions into the area of mathematics educators’ awareness of reform documents in statistics education (such as the GAISE document) or education in general (e.g. Common Core State Standards) and the curriculum implications, and pedagogical outcomes that such reform suggests. To this end, it would be beneficial for the body of literature to make exploration into the field of understanding the perceived role that mathematics educators harbor related to advancing different areas of reform, such as fostering a more statistically literate K-8 math methods student.
Finally, and perhaps most fundamentally, this study strongly reveals that research must commence related to the role of mathematics educators in the methods class and the role of the mathematics methods course in terms of teacher preparation. As P-3 adamantly held throughout this study, her K-8 math methods class is used as a platform to develop a general philosophy for teaching mathematics, whereas P-2 and particularly P-1 spend much time framing the direction of methods course around content. Future studies must parse out the perceptions of mathematics educators related to the role of a methods class, which may have been hastily assumed to be uniform and understood by members of the academy at large.

While these are but several suggestions for future research, it is clear that this study has shed new light in the areas of teacher preparation programs, the dispositions and perceptions of mathematics educators, and the advancement of statistics education reform. In sum, this study may spark new questions in non-traversed landscapes within the mathematics and statistics education literature.
APPENDICES
APPENDIX A

INFORMED CONSENT FORMS
Appendix A

Informed Consent Forms

A Phenomenological Study of Mathematics Teacher Educators’ Experiences Related to and Perceptions of Statistics

Principal Investigator: Mark D. Hogue

The purpose of this study is to highlight the experiences of K-8 mathematics methods professors’ related to a topic prevalent in mathematics education. I am interested in conducting this study since this process, evolutionary in nature, has not been detailed in the literature. You are being asked to be a part of this project.

If you decide to participate in this study, you will be asked to meet for a period of approximately 90 minutes during a time and location that is agreeable to you. During the interview, I will be asking you questions about a topic that is prevalent in mathematics education. I will audiotape the interview for the purposes of transcribing the session and subsequently interpreting your experiences and perceptions for my dissertation research. After our session, I will review the transcription of our interview. Following review of the transcription, you may be asked to participate in a brief follow-up telephone interview to reconcile any clarifications that are necessary and to answer any subsequent questions that might have been overlooked in the initial interview.

Risks

✓ With the exception of your time and any inconvenience that the interview may cause, there are no other foreseeable risks.

Benefits

✓ Throughout the interview process, you will have the opportunity to reflectively recall your experience and perception related to a prevalent topic in mathematics education.

✓ You may benefit from knowing that your experiences and perceptions may benefit the knowledge base on this subject, while contributing to future professional development opportunities in the teacher preparation arena.

Confidentiality
To protect your privacy and anonymity, pseudonyms will be used in material that will be published or publically displayed. I will further disguise, alter, or remove identifiers that could possibly reveal your identity. Furthermore, the name and location of your respective college or university will be protected. Throughout the course of the project, all audio tapes and written data will be stored in my home desk and locked, solely limiting access to the principal researcher (Mark D. Hogue). After completion of the project, the data for this study will remain in my locked home desk for an indefinite period of time, ensuring the utmost degree of confidentiality.

**Voluntary Participation**

Participation is strictly voluntary. If you choose to take part in this study, you may stop at any time during the study with absolutely no consequence. You may also skip questions that you do not wish to answer.

If you do decide to take part in this project, you will be contributing to the scholarship that has the potential to impact the ways in which teacher education programs are conceived and teacher educators are trained and receive inservice preparation. Taking part in this project is completely up to you, and there will be absolutely no consequence if you decide not to participate. If you do decide to participate in the project, you may stop at any time.

If you would like to know more about this research project, please feel free to contact me at 724-674-6841 or mhogue4@kent.edu or my advisor, Dr. Anne Reynolds, at 330-672-7031 or areynol5@kent.edu. The project has been approved by Kent State University. If you have questions about Kent State University’s rules for research, please call Dr. John West, Vice President, Division of Research and Graduate Studies (Tel. 330-672-2704).

You will receive a copy of this consent form.

Sincerely,

Mark D. Hogue  
Graduate Student, Curriculum and Instruction  
Kent State University

I agree to take part in this project. I am aware of what I have been asked to do and that I can stop at any time.

____________________________________________________  ____________________________
Signature                                    Date
AUDIOTAPE CONSENT FORM

A Phenomenological Study of Mathematics Teacher Educators’ Experiences Related to and Perceptions of Statistics

Principal Investigator: Mark D. Hogue

I agree to participate in an audio-taped interview about the perceptions and experiences related to a significant topic in mathematics education as part of this project and for the purposes of data analysis. I agree that Mark D. Hogue may audio-tape this interview. The date, time and place of the interview will be mutually agreed upon.

________________________________________________________________________
Signature                                      Date

I have been told that I have the right to listen to the recording of the interview before it is used. I have decided that I:

_____want to listen to the recording         _____do not want to listen to the recording

Sign now below if you do not want to listen to the recording. If you want to listen to the recording, you will be asked to sign after listening to them.

Mark D. Hogue may / may not (circle one) use the audio-tapes made of me. The original tapes or copies may be used for:

_____this research project _____publication _____presentation at professional meetings

________________________________________________________________________
Signature                                      Date

Address:
APPENDIX B

DEMOGRAPHIC SURVEY
Appendix B

Demographic Survey

Name: ____________________________________________

Mailing Address: ____________________________________________

City: ___________________ State: _______ Zip Code: ____________

Email Address: ____________________________________________

1. What is the title of your bachelor’s degree(s) as stated on your transcript?

____________________________________________________________________

____________________________________________________________________

2. How many undergraduate courses did you take in mathematics? ______

3. From the courses stated in question 2, how many were statistics courses? ______

4. What is the title of your master’s degree(s) as stated on your transcript? Denote equivalencies.

____________________________________________________________________

____________________________________________________________________

5. Do you have a terminal (doctoral) degree?  ■ YES  ■ NO

6. If you answered YES for question 5, do you have a:


7. If you answered YES for question 5, please state the major of your terminal degree along with your minor or cognate, if applicable.

   Major: ___________________________  Minor or Cognate: ______________

8. What are your areas of expertise? Please be descriptive.

____________________________________________________________________

____________________________________________________________________

9. What is your academic rank?

   ■ Tenure-track Faculty  ■ Tenured Faculty  ■ Temporary Part-time Instructor
   ■ Temporary Full-time Instructor  ■ Full-time Instructor  ■ Part-time Instructor

10. Do you hold, or have you held in the past, a teaching certificate?  ■ YES  ■ NO

Continued on Reverse Side

11. If you answered YES to question 9, in what state(s) do you or have you held certification?

____________________________________________________________________
12. If you answered YES to question 9, please indicate your areas of certification.


13. Do you have K-12 teaching experience?  


14. If you answered YES to question 11, in what grade spans do you have experience teaching?


15. In your current appointment, do you teach out of:


16. Please check the boxes of courses (or their equivalents) you have taught in the past.


17. Do you currently teach, or have taught within the last two years, a math methods course (or your institution’s equivalent) for elementary education majors?  


18. If you answered YES to question 16, for how many years have you taught this class? ______


19. Where is the math methods class for elementary education majors taught at your institution?


20. In terms of pedagogical content knowledge for elementary level mathematics (kindergarten thru grade 6), please rate your level of comfort (1 = novice thru 5 = expert) teaching topics in a methods and/or content class related to.


21. Would you be willing to participate in a dissertation study that seeks to investigate the understanding and experiences of professors of elementary mathematics methods courses related to a topic traditionally introduced in elementary school? Involvement would include a 90-minute interview at a site determined most suitable for you, along with a brief telephone interview, if necessary.  


Appendix C

Interview Guide

I. Greeting

A. Thank you for your willingness to participate in this study.

B. Purpose: As you know, I am interested elementary and middle school mathematics methods professors’ perceptions and experiences related to statistics.

C. Procedures: I'll be asking you a number of open-ended questions, some related to the demographic survey answers that you provided. As we have previously discussed, I need to tape-record this interview to ensure that I accurately represent your perspectives. I will also take notes throughout the interview to record critical pieces for follow-up questions and in case there are any technical difficulties. All of the tapes, transcriptions, and notes that pertain to your participation will be altered to remove any personal or institutional identification. All documents will be secured for my access, as well as the other investigator that will be active in analyzing the data that I collect.

D. Do you have any questions before we begin?

E. Review and sign two consent forms; give one to the participant.

F. Ensure that the tape recorder is loaded correctly, properly functioning, and turned on.
G. Create comfortable atmosphere and focus with general information exchange including demographic data needed to “create voice” (educational background, years in profession, experience teaching, etcetera) and then begin discussion of questions related specifically to the research questions. Move into more focused questions as appropriate.

II. Interview Questions and Framework (utilizing a semi-structured approach)

A. How important is statistics in the K-8 curriculum?

B. What do you do in your methods classes related to statistics?
   a. Content
   b. Projects and/or assignments
   c. Assessments

C. What are the big ideas that you address in your methods class related to statistics? Why are they important?

D. Are there any important distinctions between mathematics and statistics that you make to your students in methods classes?

E. Is there a difference between how the teacher should understand statistical notions for the student and how they understand it for themselves?

F. What do you think about this/these statement?
   a. “It is crucial for teachers at all levels to be statistically literate themselves and to possess the pedagogical tools necessary to provide quality learning experiences that develop and deepen their students’ statistical understanding” (Metz, 2010, p. 19).
b. “To teach statistics well, it is not enough to understand the mathematical theory; it is not even enough to understand also the additional, non-mathematical theory of statistics” (Moore, 1997, p. 803).

G. What coursework have you taken in statistics or statistics education?
   a. How has this shaped your perception of statistics in your methods class?
   b. What coursework is essential for preservice K-8 teacher candidates to have in order to understand statistical concepts in a K-8 methods course?

III. Summary Questions
   A. What experiences and related to statistics would you like to discuss that I have not addressed directly in a question?
   B. How would you generally summarize your experiences as K-8 mathematics methods professor around concepts related to statistics?

IV. Closing
   A. I am extremely appreciative for the time that you have spent sharing your perspectives and experiences related to statistics education.

Upon completion of the interviews, I will be preparing a transcript of our interview for review and may contact you in the event that clarification is necessary.
APPENDIX D

RECRUITMENT EMAIL
Appendix D

Recruitment Email

Greetings,

The purpose of this email is to determine your willingness to participate in a research study. The purpose of this study is to highlight the experiences of K-8 mathematics methods professors’ related to a topic prevalent in mathematics education. You are being asked to be a part of this project because of your role as a K-8 mathematics methods course professor.

During the interview, I will be asking you questions about a topic that is prevalent in mathematics education. Following review of the transcription, you may be asked to participate in a brief follow-up telephone interview to reconcile any clarifications that are necessary and to answer any subsequent questions that might have been overlooked in the initial interview.

If you decide to participate in this study, you will be asked to meet for a period of approximately 90 minutes during May or June 2012 at a time and location that is agreeable to you. If you are willing to participate, please reply to this email by indicating that you agree to participation, as well as five (5) dates after 4:30 PM that you are available during the month of May or the first two weeks in June 2012, as well as an amicable location for you to meet that would be conducive for a private interview.

Finally, and only if you are willing to participate, please find the Demographic Survey as an attachment to the email. Please complete the document to the best of your ability by completing the appropriate fields and checking the appropriate boxes that best describe you. Then, save the file to your computer and attach it to your reply email.

If you have any questions at all regarding this study, feel free to reach me through the contact information below my signature. You may also contact my advisor, Dr. Anne Reynolds, at areynol5@kent.edu with any questions. Thank you in advance for your assistance!

Sincerely,

Mark D. Hogue
Graduate Student, Curriculum & Instruction
Kent State University
mhogue4@kent.edu
724-674-6841
APPENDIX E

BRACKETING / RESEARCHER REFLEXIVITY
Appendix E
Bracketing / Researcher Reflexivity

In my heart of hearts, irrespective of the fact that I am an ardent traditionalist in many social matters and trend towards thinking about rather customary research questions, I am a constructivist in terms of my vision for teaching and learning. Thus, I would frame my pedagogical identity, which I do not confuse as my political or research lens, as a constructivist. As a student and teacher, I subscribe to a rich conceptual understanding of mathematical and statistical phenomena. I believe that students play an active role in the dynamic process of constructing knowledge, and this critical experience, formed from meaningful student-centered engagement, undergirds the foundation of knowledge. I thoroughly endorse a Vygotskyian-framed vision for teaching practices, whereby my students are immersed in their learning through the responsive constructs of culture, interaction, and social position.

As a researcher, it is critical that I bracket my biases so that I am aware of my foundational positions on matters critical to my study. To this end, I possess a bias when considering professors’ educational backgrounds. I feel that while some professors of elementary education mathematics methods courses have an extremely strong background in the scientific underpinnings of mathematics, I feel that a there must be a strong basis in pedagogy of that content (PCK) in order for such teachers to properly deliver the content in a meaningful, authentic way. Further, I am biased in terms of thinking about statistics as a field that does not conform to the straight lines teaching that
some math educators may harbor. I believe, rather, that knowledge of mathematics content, pedagogy, and pedagogical content knowledge is not synonymous with knowledge of statistical pedagogical content knowledge. Specifically, this belief is grounded in my understandings of K-8 relevant statistical knowledge (in particular reference to my study) and the multiple ways of representing and expressing its characteristics in educationally sound ways. This belief has been concreted in my experiences as a teacher and in my studies as a future mathematics educator.

I expect that some participants may discuss statistics to an extent that I may feel is inadequate for a teacher educator. Specifically, I believe that some math educators that I interview may perceive statistics as simply a way of reporting a representative data value for a sample or population, yet not understand the statistical significance that it implies. I feel that it is integral that I remain cognizant not to prejudge or show expression of my discontentment if such is the case and uphold the purposes of research to seek to understand each instructor’s perception of this technology with the ultimate goal of enhancing the literature base.

Furthermore, from a researcher’s perspective, I am highly interested in engaging in small community of educators to assist in my reflexive processes (Mauthner & Doucet, 2003). I feel that this process of remaining reflexive throughout the data collection and analysis phase will profoundly promote the identification of the undergirding constructs which inform my epistemological and ontological perspectives. To this end, I believe that working with another researcher, Mr. Rich Busi, throughout the data analysis phase (promoting investigator triangulation) will also assist my reflexivity. Moreover, in such a
community of educators and researchers, I feel that I will be better suited to stay on task and on target throughout the data analysis and interpretation portions of my project.

While I have yet to firmly situate myself as researcher, it is helpful for me to frame my beliefs and experiences through the socio-educational stimuli that I continuously interact with. In the future, I believe that I would like to be known as both a quantitative and qualitative seeker of knowledge through research questions that are purposeful and meaningful. I believe that the awareness of my positioning supports ongoing critical interrogation of teacher education practices and programs, while acknowledging my orientation towards desiring to have a community of mathematics educators who are well versed in statistical ideas.
APPENDIX F

BRACKETING STATEMENT RELATED TO STATISTICS EDUCATION

RICH BUSI, DOCTORAL STUDENT, UNIVERSITY OF FLORIDA
Appendix F

Bracketing Statement Related to Statistics Education

Rich Busi, Doctoral Student, University of Florida

Despite common conceptions, statistics is a very unique field of study distinct even from that of traditional mathematics. There are several fundamental differences between mathematics and statistics, but at the heart of these differences lie the focus on certainty. Uncertain observations that are impossible with the principles of mathematics are easily tackled and embraced by the statistical realm. Where mathematics is certain and predictable, statistics encircles the uncertainty of the world in which we live. Therefore, educating individuals to use and understand statistics is as unique an endeavor as the field itself. Furthermore, it is of utmost importance.

It is a critical time to focus on the improvement of statistics education. Although statistics remain rampant in everyday life – from commercials, to product labels, to newspapers, to politics – they are all but removed from the upcoming mathematics standards documents. The lack of time created by this omission inadvertently creates a salient need for research that is aimed at understanding how to teach statistics with a limited time. Ultimately, it is imperative to study and maximize the efficiency of statistics teaching and learning.

A main goal of statistics education research must be to define and promote statistical literacy. As an applied subject, statistics must prepare individuals to be successful in interpreting and understanding the information society presents to them. In
order to do this, statistics education must provide opportunities for individuals to
construct knowledge that is applicable and transferrable from the classroom to everyday
life. Moreover, statistics education must find ways to attract and retain students who
have traditionally dropped out of advanced levels of statistics.
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