ACCEPTANCE

This dissertation, HIGH SCHOOL STUDENTS' ATTITUDES AND BELIEFS REGARDING STATISTICS IN A SERVICE-LEARNING BASED STATISTICS COURSE, by JENNIFER LYNN LEONG, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

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

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ABSTRACT

HIGH SCHOOL STUDENTS' ATTITUDES AND BELIEFS REGARDING STATISTICS IN A SERVICE-LEARNING-BASED STATISTICS COURSE

by

Jennifer Leong

Despite agreement among researchers about the powerful influence of attitudes and beliefs on the development of students' mathematical knowledge base (Leder, Pehkonen, & Törner, 2002), relatively little is known about these constructs in statistics education. This study investigated the relationship between mathematics-and statistics-related attitudes and beliefs of 11 high school students in an introductory statistics course designed around a 13-week long service-learning project. Service-learning is a pedagogical approach that situates academic learning in the context of community service.

The study utilized qualitative, teacher-researcher (Cochran-Smith & Lytle, 1993) methodology from an interpretivist perspective. The three primary modes of data collection were journals, narratives, and an open-ended survey (Survey of Mathematical and Statistical Affect). Observations and reflections were also recorded regularly in a researcher journal. Inquiry adhered to guidelines for trustworthiness and rigor as outlined by Lincoln and Guba (1985). Item, pattern, and structural levels of analysis were employed (LeCompte and Schensul, 1999b). Investigation into attitudes and beliefs was framed in accordance with Op t' Eynde, De Corte, and Verschaffel's (2002)

conceptualization of the mathematics-related belief system and McLeod's (1992) framework of the affective domain in mathematics education.

Results indicate that participants' attitudes toward mathematics and statistics tended to converge while participants' beliefs regarding mathematics and statistics tended to diverge. Participants like mathematics and statistics that involve real-life scenarios. Participants also like mathematics and statistics that do not require complex mathematical tasks. Participants' beliefs regarding statistics were generally more positive than beliefs regarding mathematics. Participants reported greater confidence doing statistics than mathematics and contribute this confidence, in part, to service-learning. Participants also experienced a heightened sense of social awareness and social responsibility through the service-learning project. These results provide evidence that service-learning can be utilized to solidify positive attitudes and beliefs regarding statistics among high school students, in spite of potentially less positive ones toward mathematics.

HIGH SCHOOL STUDENTS' ATTITUDES AND BELIEFS REGARDING STATISTICS IN A SERVICE-LEARNING-BASED STATISTICS COURSE

by

Jennifer Leong

A Dissertation

Presented in Partial Fulfillment of Requirements for the
Degree of
Doctor of Philosophy
in
Teaching and Learning
in
the Department of Middle and Secondary Education and Instructional Technology
in
the College of Education
Georgia State University

Atlanta, GA

2006

ACKNOWLEDGMENTS

Throughout the entire process of my doctoral program, I have relied on the support of so many tremendous people. First, I would like to express my sincere gratitude to my parents, Albert and Hazel, for their unconditional love and support, and to the rest of my family for believing in me.

To Amy and my wonderful friends, thank you for your love and encouragement. I appreciate your persistent efforts to accommodate my schedule and to make time for me. Thank you for keeping me grounded.

I would also like to thank the students in my Functions and Statistics course for their participation in the study and our community partner for the good work it does. I appreciate my administration and colleagues as well, for providing professional support, encouragement, and friendship.

I wish to express my utmost gratitude to the members of my dissertation committee, Christine Thomas, Steve Harmon, Joel Meyers, and Draga Vidakovic. For without the wisdom and guidance of this extraordinary committee, this work would not have been possible. Thank you for the generosity of your time, your helpful and timely feedback, and for creating an environment where I could safely and surely grow in scholarship.

Finally, I extend special thanks to my dissertation committee chair, Christine Thomas, for taking extra time to provide me with individual attention and support. Thank

you for challenging and inspiring me and for modeling exceptional scholarship and leadership.

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CHAPTER 1

INTRODUCTION

The basis of this study is a problem that is derived from multiple fields - mathematics education, statistics education, and service-learning. Therefore, to establish the background and rationale of the study, I begin by introducing pertinent concepts and research in these three areas. A brief overview of mathematics education reform in recent years is provided with a focus on the elements relevant to this study, namely, components pertaining to attitudes, beliefs, and statistics education. Then, the concept of service-learning is introduced and a definition is provided. Next, the purpose statement and the research questions are stated, followed by an explanation of the conceptual framework of the study and additional operational definitions. The chapter closes with a summary of this introduction.

Background and Rationale

Mathematics Education Research and Reform

For years, U.S. students have fared poorly in mathematics compared to their international counterparts. In response, there have been ongoing efforts over the past two decades by educators, researchers, and policy makers to significantly reform mathematics education in the U.S. However, reports such as the National Assessment of Educational Progress (Perie, Grigg, & Dion, 2005), the Trends in International Mathematics and Science Study (Mullis, Martin, & Gonzales, 2004), and the Program for International

Student Assessment (Lemke & Gonzales, 2006) confirm students' continued inadequacies. In the year 2000, The National Council of Teachers of Mathematics (NCTM) published the *Principles and Standards for School Mathematics*, a revision and compilation of three previous publications, the *Curriculum and Evaluation Standards for School Mathematics* in 1989, the *Professional Teaching Standards for School Mathematics* in 1991, and the *Assessment Standards for School Mathematics* in 1995. The *Principles and Standards for School Mathematics* is a national curriculum that delineates characteristics of classroom experiences from pre-kindergarten through 12th grade in accordance with a standards-based mathematics reform agenda. It outlines six guiding principals (equity, curriculum, teaching, learning, assessment, and technology), six content standards (number and operations, algebra, geometry, measurement, data analysis and probability, problem solving), and four process standards (reasoning and proof, communications, connections, and representations).

> The Principles describe particular features of high-quality mathematics education. The Standards describe the mathematical content and processes that students should learn. Together, the Principles and Standards constitute a vision to guide educators as they strive for the continual improvement of mathematics education in classrooms, schools, and educational systems. (NCTM, 2000, p. 11)

One goal of mathematics education reform is to improve students' disposition toward mathematics because research has clearly established that affective factors, as well as cognitive ones, play a key factor in the development of a student's mathematical knowledge base (Gómez-Chacón, 2000; Leder & Forgasz, 2002; Leder, Pehkonen, & Törner, 2002; McLeod, 1988, 1992; Op t' Eynde, De Corte, & Verschaffel, 2002; Schweinle, Turner, & Meyer, 2002). Mathematics-related attitudes and beliefs have been found to become increasingly less positive during secondary school (Ma, 2003; Wilkins

& Ma, 2003). Students typically believe mathematics to be a solitary, isolating activity involving mostly memorization and loosely connected rules and procedures (Mtetwa & Garafalo, 1989; Schoenfeld, 1992). The pervasiveness of these beliefs is problematic because they are consistent with a view of mathematics as a static, unimaginative subject and, therefore, negatively influence students' disposition toward mathematics (NCTM, 1989).

Another component of the mathematics education reform agenda is a modification in the curriculum to include a greater emphasis on statistics education. It calls for the integration of statistics concepts throughout the curriculum from pre-kindergarten through high school. Thus, by the end of high school, students should have a comprehensive understanding of introductory data analysis and probability concepts (NCTM, 2000). Prior to this curriculum modification, it was not unusual for a student's first course in statistics to occur in college. With increased frequency in the appearance of stand-alone, high school statistics courses, comes an opportunity to establish positive attitudes and beliefs regarding statistics among high school students, despite potentially less positive attitudes and beliefs regarding mathematics in general.

Before proceeding, an important clarification should be made. In the discussion that follows, it may appear that statistics education and mathematics education are treated as separate disciplines, but certainly, they are not mutually exclusive. To explain, Törner (2002) proposes a tri-level hierarchical belief structure. At the broadest level are "global beliefs" that include general beliefs like "beliefs on the teaching or learning of mathematics, on the nature of mathematics, and on the origin and development of mathematical knowledge" (p. 86). Narrowing the scope, Törner refers to "domain-

specific beliefs" which refer to beliefs associated with different mathematical domains like geometry, statistics, and calculus. At the most specific level, Törner defines "subject-matter beliefs" which refer to more concrete "beliefs objects" (p. 78) like mathematical facts (e.g. the Pythagorean theorem, rules of differentiation, concept of slope, etc.). Therefore, attitudes and beliefs can be examined on a global level (regarding mathematics) and on a domain-specific-level (regarding statistics).

The belief system as it pertains to mathematics has been researched fairly extensively, whereas the belief system as it pertains to statistics remains relatively unexplored. It is undisputed that attitudes and beliefs associated with these two fields are interrelated in some way. However, the extent to which mathematics-related attitudes and beliefs parallel statistics-related attitudes and beliefs has yet to be established. Therefore, inquiry into statistics-related attitudes and beliefs should also involve inquiry into mathematics-related attitudes and beliefs. One of the goals of this study was to shed light on the relationship between mathematics-related and statistics-related attitudes and beliefs.

Though a larger body of research is needed, initial studies suggest that attitudes and beliefs regarding statistics are a function of at least three sources: previous experiences with statistics, beliefs regarding the nature of statistics (e.g. statistics involves making graphs and finding percentages), and attitudes and beliefs about mathematics that have simply been transferred to statistics (Gal, Ginsburg, & Schau, 1997). Initial studies also suggest that affective factors influence teaching and learning processes, students' statistics-related behaviors beyond the classroom, and students' decision to pursue statistics in the future (Gal, Ginsburg, & Schau, 1997).

It is vital for teachers to monitor students' affective responses because teachers can develop and change students' beliefs about learning by the way they establish social norms in the classroom and in their selection and implementation of tasks (Lester, 2002). If teachers hold high expectations and choose challenging activities that promote investigation and demonstrate a clear relationship to everyday life, teachers can positively impact students' beliefs and attitudes toward mathematics and statistics (Middleton & Spanias, 1999; Wilkins & Ma, 2003). The data driven nature of statistics lends itself to real world investigations. Teaching statistics using projects based on real world data gives contextual meaning to statistical tasks (Cobb, 1993; Fillebrown, 1994; Vaughan, 2003). One way to teach statistics utilizing data that is clearly anchored in the real world is through service-learning.

Service Learning

Service-learning is "a method in which students learn experientially and actively through participation in meaningful service that meets actual community needs and is linked to the academic curriculum" (Cumbo & Vadeboncoeur, 1999, p. 85). Service-learning can take on a variety of forms but contains two essential components (Strage, 2000). First, the focus must be on *reciprocity* between those providing the service and those receiving the service. That is, high quality service is exchanged for high quality learning opportunities. Secondly, there must be some form of structured *reflection* incorporated in the service-learning experience, helping the learner to construct meaning throughout the learning process.

A significant body of research has established that service-learning can have a powerful impact on personal and social outcomes like sense of self-identity, sense of

social responsibility, confidence in relationship building and citizenship skills, and perceived self-efficacy (Eyler, Giles, & Grey, 1999; Giles & Eyler, 1998, McKenna & Rizzo, 1999; Moore & Sandholtz, 1999; Scales, Blyth, Berkas, & Kielsmeier, 2000). The current research agenda in the field of service-learning calls for more studies pertaining to academic outcomes associated with service-learning (Kraft & Krug, 1994; Steinke & Buresh, 2002). One of the reasons why this kind of research has been slow to develop is because it is difficult to "identify and measure appropriate learning outcomes that service-learning may be uniquely designed to affect" (Giles & Eyler, 1998, p. 67).

One way to address this problem is to design research that identifies domain-specific personal and social outcomes associated with service-learning that are also good predictors of achievement within that domain. For example, statistics self-efficacy is a good predictor of statistics achievement provided both statistics self-efficacy and achievement are measured on a task-specific basis (Finney & Schraw, 2003). However, there is insufficient research about the influence of service-learning on statistics-related attitudes and beliefs. Studies like this one that shed light on this relationship are needed so that future research attempting to connect service-learning and statistics achievement may have a foundation upon which to build.

The body of literature pertaining to service-learning-based statistics is largely underdeveloped, particularly with regard to scholarly research and to studies involving high school students. However, initial reports indicate that service-learning can positively influence statistics students' levels of motivation (Anderson & Sunger, 1999; Root & Thorme, 2001; Thorme & Root, 2002; Truran & Arnold, 2002), perceived usefulness of statistics (Cushner, 2003; Duke, 1999; Evangelopoulos, Sidorova, & Riolli, 2003), and

attitudes toward statistics (Cushner, 2003; Evangelopoulos, Sidorova, & Riolli, 2003). While these reports are promising, there is still much work to be done towards establishing anticipated outcomes – personal, social, and academic – associated with service-learning-based statistics. Through this study, I attempt to make a contribution toward closing this gap in the literature by investigating attitudes and beliefs toward statistics in a service-learning-based, high school statistics course, taking special care to ground the study in scholarly literature and theory and to employ rigorous research methods.

Purpose Statement and Research Questions

There were two main purposes of this study. The first purpose was to examine the relationship between high school students' attitudes and beliefs regarding mathematics and those regarding statistics. The second purpose was to investigate high school students' perceptions of the influence of service-learning on the development of their own attitudes and beliefs regarding statistics.

Using qualitative action research methodology, I investigated the attitudes and beliefs regarding mathematics and statistics of 11 high school students in a service-learning-based introductory statistics course, of which I was the teacher. Research was approached from the perspective of an interpretivist paradigm. The research questions for this study were as follows:

1. What are high school students' attitudes and beliefs regarding mathematics and statistics, respectively? In particular, what were students' general beliefs about the nature and utilization of mathematics and statistics, beliefs about what it means to

do mathematics and statistics, and beliefs about confidence to do mathematics and statistics?

2. To what extent do high school students' mathematics-related attitudes and beliefs parallel their statistics-related attitudes and beliefs?

3. What are high school students' perceptions of the role of service-learning in influencing their confidence to do statistics? What are students' attitudes toward service-learning? What other service-learning outcomes do students report?

Next, I explain the conceptual framework that supported the study as well as key definitions.

Conceptual Frame and Operational Definitions

Despite the progress in research pertaining to the mathematics belief system, it has tended to lack conceptual clarity. Op t' Eynde, De Corte, and Verschaffel (2002), conducted a comprehensive examination of literature pertaining to the mathematics-related belief system. The review began with 119 articles published from 1984 to 2000 and was narrowed down to 50 articles that focused on student beliefs about mathematics and/or presented a model for examining these beliefs. Through this analysis, they produced a concrete definition of students' mathematics-related beliefs and subsequently, a theoretical model of students' mathematics-related beliefs that integrates the work of leading researchers.

The lack of consistency in defining mathematics-related beliefs is problematic in the research (Törner, 2002). McLeod and McLeod (2002) conclude that no single definition of the term "belief" is correct and that different audiences have different needs that require informal or more formal definitions. For a scholarly audience, a more formal

definition in required. Op t' Eynde, De Corte, and Verschaffel (2002) completed the challenging task of synthesizing a broad body of literature to determine such a definition. They identify three key dimensions of mathematics-related beliefs -beliefs about mathematics education, beliefs about the self, and beliefs about the classroom context (because beliefs are fundamentally social). Thus, the formal and concrete definition of mathematics-related beliefs that unfolded is as follows:

> Students' mathematics-related beliefs are the implicitly or explicitly held subjective conceptions students hold to be true about mathematics education, about themselves as mathematicians, and about the mathematics class context. These beliefs determine in close interaction with each other and with students' prior knowledge their mathematical learning and problem solving in class. (Op t' Eynde, De Corte, & Verschaffel, 2002, p. 27)

The theoretical model of the mathematics-related belief system follows directly from this concrete definition and integrates the work of primarily four leading researchers, Robert Underhill, Douglas McLeod, Peter Kloosterman, and Erkki Pehkonen. The model consists of the same three main belief categories but with subcategories for each one. Beliefs about mathematics education consist of three subcategories - beliefs about mathematics as a subject, beliefs about mathematical learning and problem solving, and beliefs about mathematics teaching in general. Beliefs about the self consist of four subcategories - self-efficacy beliefs, control beliefs, task-value beliefs, and goal-orientation beliefs. Beliefs about the social context consist of two subcategories - beliefs about social norms in students' own class regarding the role and functioning of both the teacher and students, and beliefs about the socio-mathematical norms in students' own class.

Historically, mathematics education research has tended to approach the study of beliefs from a cognitive perspective (Goldin, 2002). However, more recent research has recognized mathematical beliefs as having both affective and cognitive components (see Gómez-Chacón, 2000; Higbee & Thomas, 1999; Hsiu-Zu Ho et al., 2000; Leder & Forgasz, 2002; Pietsch, Walker, & Chapman, 2003). For example, McLeod (1992) positions beliefs within a framework of the *affective* domain in mathematics education. Beliefs represent one component of the framework. Attitudes and emotions are the other two components. Attitudes are defined as "positive and negative feelings of moderate intensity and reasonable stability" (McLeod, 1992, p. 581). Attitudes include feelings like curiosity, boredom, like, or dislike. Emotions refer to the affective responses that change rapidly, like joy or frustration in solving mathematical problems.

McLeod's framework represents a continuum of dimensions within the affective domain. Malmivouri (2001) explains how McLeod's conceptualization of beliefs, attitudes, and emotions is:

> …a list of various affective factors in order of increasing affective involvement, decreasing cognitive involvement, increasing intensity, and decreasing stability. Accordingly, mathematical beliefs are classified as pupils' affectively intertwined constructs or responses having the largest amount of cognitive involvement and least amount of affective involvement, together with low intensity and high stability. (p. 48)

In other words, beliefs include both affective and cognitive components. Furthermore, beliefs are distinguishable from attitudes and emotions along this continuum. This is contradictory to some research that uses the terms "beliefs" and "attitudes" interchangeably (Malmivouri, 2002). Such blurring of terms is counterproductive to establishing conceptual clarity and cohesiveness as a body of literature (McLeod, 1992).

The term "affect" is referenced by different educators and researchers to mean a variety of constructs and processes like beliefs, attitudes, tastes, appreciations, emotions, and preferences (McLeod, 1991). Thus, different studies attempting to examine affective influences on mathematical knowledge may have different outcomes depending on the affective construct truly under examination.

Clearly, it is important to establish a well-defined conceptual framework in any study, but particularly in one with such a cloudy background. Thus, in my study of mathematics-related attitudes and beliefs, I adopt Op t' Eynde, De Corte, and Verschaffel's (2002) definition of mathematics-related beliefs and I define statistics-related beliefs similarly, replacing "mathematics" with "statistics". Also, I adopt McLeod's (1992) definition of attitudes. Furthermore, I borrow from Op t' Eynde, De Corte, and Verschaffel's (2002) framework of students' mathematics-related beliefs and McLeod's (1992) conceptualization of the affective domain in mathematics education to establish the conceptual framework applied to this study (see Table 1).

This study examined a subset of Op t' Eynde, De Corte, and Verschaffel's and McLeod's framework on a global (mathematics) and domain-specific (statistics) level. The study investigated high school students' attitudes toward mathematics and statistics, beliefs about mathematics and statistics education, and beliefs about the self as a learner and doer of mathematics and statistics. More specifically, the study examined general beliefs about the nature and utilization of mathematics and statistics, beliefs about what it means to *do* mathematics and statistics, and confidence in doing mathematics and statistics.

Table 1

Conceptual Framework of Mathematics and Statistics-Related Attitudes and Beliefs

Category	Subcategory	Examples
Beliefs about mathematics and statistics education	General beliefs about the nature and utilization of mathematics and statistics	Mathematics is based on rules. Statistics is based on people.
	Beliefs about what it means to *do* mathematics and statistics	Doing math means doing homework. Doing statistics means collecting data.
Beliefs about the self	Beliefs about confidence to do mathematics and statistics (self-efficacy beliefs)	I'm not confident in doing trigonometry. I'm confident I can read a bar chart.
Attitudes	Not applicable	I like math when it feels easy or familiar.
		I dislike probability.

Summary of the Introduction

In an effort to address the low to mediocre mathematics performance of U.S. students, the field of mathematics education has been under reform over the past several decades. The reform agenda outlines principles and guidelines for the teaching and learning of mathematics, among which is a focus on improving students' attitudes and beliefs regarding mathematics and the integration of statistical reasoning and data analysis throughout the curriculum. With the growth of statistics education comes a need

for a greater body of research within this domain-specific field of mathematics. In particular, research is needed that examines the relationship between attitudes and beliefs regarding mathematics and those regarding statistics.

One approach to teaching statistics that has warranted attention in recent years is service-learning. By situating academic learning with the context of a community service project, service-learning has the potential to help students make meaningful connections between statistics and the real world. In the social sciences, service-learning has shown to positively influences students on a personal and social level. However, little research exists on outcomes associated with service-learning-based statistics, particular among high school students.

This study addresses both of the aforementioned gaps in the literature. It examines the relationship between students' mathematics- and statistics-related attitudes and beliefs as well as the role of service-learning on the development of high school students attitudes and beliefs regarding statistics. For conceptual clarity, a framework of attitudes and beliefs was applied that combines the work of Op t' Eynde, De Corte, and Verschaffel (2002), and McLeod (1992). In addition to attitudes toward mathematics and statistics, specific beliefs examined were general beliefs regarding the nature and utilization of mathematics and statistics, beliefs about doing mathematics and statistics, beliefs about confidence to do mathematics and statistics. Accordingly, the research questions for the study align with these intended goals.

In the next chapter, I elaborate on the ideas introduced here. I set the stage for the study with a review of the literature pertaining to attitudes and beliefs regarding

mathematics and statistics and to service-learning in statistics. In addition, I establish the theoretical framework of the study.

CHAPTER 2

LITERATURE REVIEW

Organization and Rationale

The literature reviewed for this study is organized into three main sections: attitudes and beliefs regarding mathematics and statistics, service-learning and statistics, and relevant theories. Each section was selected with a clear purpose in mind. I begin by reviewing background literature pertaining to attitudes and beliefs about mathematics and statistics. I found that much of this literature focuses on attitudes and beliefs in relation to achievement. Therefore, an overview of what is known in that regard is provided. Problems related to this literature are highlighted as well as important findings. In addition, this section considers the relationship between statistics-related attitudes and beliefs and various approaches to teaching. This leads to the next section that reviews the literature pertaining to service-learning and statistics. Anticipated benefits of service-learning and a rationale for more research in this area are established. The last section reviews two main theories that played a role in the research design. First, I explain the underlying theoretical perspective of the study with a discussion of Deweyian theory. Finally, I provide a review of self-efficacy theory as well as a rationale for its application to the study. Even more detailed explanations of how this literature and these theories guided data collection and data analysis is provided in Chapter 3.

Mathematics- and Statistics-Related Attitudes and Beliefs

Much of the research pertaining to attitudes and beliefs involves studies aiming to measure outcomes in terms of achievement. Thus, I concentrate the discussion that follows on this relationship with emphasis in statistics, drawing from the literature in mathematics when relevant. While this study is not oriented toward achievement outcomes, the literature in this area still has important implications.

The literature in statistics education pertaining to attitudes and beliefs and their relation to achievement in statistics is problematic for three reasons. First, it is underdeveloped, especially in studies pertaining to secondary students. Second, there is an inconsistency in the use of terminology related to attitudes and beliefs. Third, the research is dominated by quantitative methods of data collection, mostly in the form of lickert-type questionnaires that provide a limited depth of inquiry.

The problem of inconsistency among attitude and belief terminology is carried over from mathematics education. Educators and researchers judge attitudes toward mathematics using a variety of constructs, like self-concept, confidence, anxiety, self-efficacy, and beliefs about the usefulness of mathematics. This lack of a common language causes difficulty in creating a cohesive body of literature of any real power. For this reason, Op t' Eynde, De Corte, and Verschaffel's (2002) and McLeod's (1992) frameworks referenced earlier in this paper are especially important tools for interpreting and conducting related research. In the discussion that follows, I examine several commonly referenced instruments used to measure statistics-related attitudes and beliefs,

overlaying them with these frameworks to point out commonalities and discrepancies in terminology.

Practically all studies regarding attitudes toward statistics have utilized some form of paper-pencil likert-type scale (Gal & Ginsburg, 1994). Three commonly referenced scales are the Attitude Toward Statistics (ATS) scale (Wise, 1985), the Statistics Attitude Survey (SAS) (Roberts & Bilderback, 1980), and the Survey of Attitudes Toward Statistics (SATS) (Schau, Stevens, Dauphine, & Del Vecchio, 1995). Gal and Ginsburg (1994) discuss limitations of these instruments and others like them. First, these instruments do not account for the fact that students' responses may reflect attitudes toward and beliefs about mathematics, which they may confuse with attitudes toward or beliefs about statistics. Closed-ended questionnaires do not allow students to explain the meaning behind responses or elaborate on them in a way that might provide insight into the matter. Second, students' responses to items designed to measure perceived usefulness of statistics in future occupations depend on the students' knowledge of content and requirements for future careers. This level of knowledge is greatly individualized and varies from student to student. Third, students in an introductory statistics course are not likely to have a clear understanding of what it means to *do* statistics, yet these scales ask questions that require some concept of its meaning. Finally, using current assessment instruments, Gal and Ginsburg (1994) question how to identify changes in scores that are educationally versus statistically significant.

Examined through Op t' Eynde, De Corte, and Verschaffel's (2002) and McLeod's (1992) frameworks, the ATS, the SAS, and the SATS measure constructs other than just attitudes. The ATS is broken into two subscales, a field subscale and a

course subscale. The field subscale is designed to measure attitudes toward the field of statistics in general, but actually is oriented more towards assessing beliefs about the usefulness of statistics. The course subscale is designed to measure attitudes towards a statistics course. The course subscale measures attitudes in a way that is more consistent with McLeod's concept of attitudes, that is, as positive and negative feelings about a statistics course.

The SAS does not explicitly distinguish between any subscales among its 33 items. However, applying Op t' Eynde, De Corte, and Verschaffel's and McLeod's frameworks, items could be classified according to measures such as attitude (e.g., "I would like to study advanced statistics."), beliefs about the nature of statistics (e.g., "You should be good at math before attempting statistics."), and beliefs about the self (e.g., "Even before I begin a new statistics topic, I feel relatively confident that I can master it").

The SATS is broken into four components: cognitive competence, value, difficulty, and affect. The cognitive competence component assesses self-beliefs about ability in statistics. The value component assesses beliefs about the usefulness and importance of statistics. The difficulty component assesses beliefs about the difficulty of statistics based on beliefs about the nature of statistics. The affect component assesses positive and negative feelings about statistics.

Except for the manner in which the four components of the SATS are named, they fit well into McLeod's framework. On the SATS, attitude is referred to as *the* affective component, whereas McLeod refers to attitude as one category of the affective domain.

The other components on the SATS frame beliefs similarly to McLeod's framework as beliefs about statistics and beliefs about the self.

Without an explicitly shared conception of the affective domain in statistics education, it can be difficult to interpret and synthesize studies that utilize instruments like the ATS, SAS, or the SATS. In addition, the closed ended scales used in all of these instruments and in others like them limit the usefulness of results because they do not allow for investigation into the processes, experiences, and interpretations behind attitudes and beliefs (Gal & Ginsburg, 1994). These problems may help to explain the mixed results in the literature regarding the relationship between statistics-related attitudes and beliefs and statistics achievement.

Some researchers have found that attitudes toward statistics and achievement in statistics are related. Kottke (2000) found attitudes towards the statistics course and application to chosen field of study to be positively correlated with statistical competency and course grades among upper-level college students. Sorge (2001) found that for undergraduate engineering students enrolled in a statistics course, both prior achievement and attitudes towards statistics, as measured using the SATS, were related to achievement in statistics. Similarly, Johnson (1996) found current GPA to be the best predictor of achievement followed by attitudes toward statistics in a study of graduate students enrolled in an introductory statistics course.

Other researchers have found that attitudes toward statistics are not related to achievement in statistics. Cashin (2001) studied masters and doctoral students in an inferential statistics course and found that while mathematics self-concept and statistics self-efficacy were predictors of performance, attitudes toward statistics, measured using

the ATS, were not a significant predictor of achievement in statistics. Perney and Ravid (1990) found similar results in a study of graduate level statistics students. Course performance was not related to attitudes toward statistics, mathematics self-concept, mathematics background, or attitudes toward tests. Students' perception of the course instructor, however, was found to be related to course performance. Birenbaum and Eylath (1994) found that statistics anxiety had statistically significant negative correlations with willingness to further pursue statistics, but that neither statistics anxiety nor willingness to further pursue mathematics were related to statistics course grades. However, inductive reasoning ability had statistically significant correlations with statistics anxiety and statistics course grade, but not with mathematics anxiety.

Since the literature pertaining to attitudes and beliefs about statistics is inconsistent and underdeveloped, it is useful to examine the larger body of literature on this topic in the related, broader field of mathematics. In a three-year, longitudinal study of first- through fourth-graders, Kloosterman, Raymond, and Emnaker (1996) found that elementary school students tend to believe that mathematics is useful, though they may not be able to explain why and that anyone can learn mathematics. The study also indicated that confidence in mathematics, once formed, is relatively stable, and that attitudes toward mathematics become more positive as mathematics becomes more challenging. However, Ma (2003) found that students' attitudes toward mathematics became increasingly more negative during middle school and with the most significant changes among students in regular level mathematics (versus gifted or honors) who were placed in an early acceleration track (taking Algebra I in the seventh or eighth grade).

Therefore, at some point, perhaps in middle school, more challenging mathematics does not necessarily produce more positive attitudes toward mathematics.

Once students reach high school, attitudes toward mathematics and beliefs about the social importance of mathematics still tend to decline, but less dramatically than in middle school; beliefs about the nature of mathematics remain relatively stable (Ma & Kishnor, 1997; Wilkins & Ma, 2003). Among the commonly held beliefs about the nature of mathematical problem solving include a belief that mathematics problems have only one way to be solved, that is, by memorizing what the teacher has demonstrated in order to get one correct answer (Schoenfeld, 1992). Beliefs such as this coincide with a teacher-centered approach to learning that leave little room for students' experiences to aid in making meaning and connections between concepts.

It is important to understand the sources of negative attitudes and beliefs if they are to be improved. Wilkins and Ma (2003) found that teacher encouragement influences attitudes toward mathematics in both middle and high school, that peer influence plays a significant role in developing attitudes toward mathematics during high school, and that parental attitudes and beliefs about mathematics can significantly influence students' beliefs about the social importance and the nature of mathematics. Most importantly, teachers are in a key position to positively influence mathematical affect and achievement by carefully designing instruction that utilizes strategies shown to improve attitudes and beliefs (Middleton & Spanias, 1999). It is reasonable to assume that the factors that influence attitudes and beliefs in mathematics also influence attitudes and beliefs in statistics.

Studies have shown that certain instructional strategies in statistics education can positively influence statistical affect and achievement, like the use of cooperative learning and the integration of technology (Bratton, 1999; Holcomb & Ruffer, 2000; Keeler & Steinhorst, 1995; Lane & Maja, 2002; Mills, 2004; Prvan, Reid, & Petocz, 2002; Townsend & Wilton, 2003). In the real world, statisticians rely heavily on computer technologies to perform computations that would otherwise be unreasonably laborious. Similarly, technology such as graphing calculators, statistical computing software, and spreadsheets enable students to move beyond the potentially debilitating computational aspects of statistics to the more conceptual aspects that lead to deeper levels of understanding.

Mvududu (2003) reported that perceptions of personal relevance of statistics to everyday life were the greatest predictor of attitudes toward statistics. One way to establish personal relevance and to encourage active learning is to use real data sets or to use student generated data in statistics courses. Bradstreet (1996) found that students' attitudes toward statistics improved through the use of instructional methods that include "recognizing and evaluating statistical anxiety in students, inviting active learning (while minimizing passive learning), using realistic data and graphics, and implementing intimate teaching techniques in a situated learning environment" (p. 77). Other research confirms the positive effects on statistics achievement and statistics-related attitudes and beliefs through the use of projects that use real or student-generated data (see Fillebrown, 1994; Holcomb & Ruffer, 2000; Mackisack, 1994; Smith, 1998). Service-learning projects are one such example.

To summarize, the literature from statistics education on the relationship between attitudes toward statistics and achievement in statistics suffers from lack of substance and breadth, inconsistency in terminology, and the pervasive use of fundamentally flawed assessment instruments that do not allow for inquiry of adequate depth. The framework for students' mathematics-related beliefs according to Op t' Eynde, De Corte, and Verschaffel (2002) and the affective domain in mathematics education according to McLeod (1992) provide an excellent starting point for clarifying terminology among researchers in this area and for initiating some conclusions about the nature of the relationship between attitudes toward statistics and achievement in statistics. Further, the incorporation of qualitative methods of inquiry like interviews, observations, journal writing, open-ended surveys, and focus groups can provide deeper insights into the relationship between attitudes toward and beliefs about statistics and achievement in statistics. The research that is available in this area yields mixed results, but this could be due to the problems in the literature mentioned above.

The literature shows that attitudes and beliefs about mathematics become more negative as students move from elementary school to high school. Teachers, peers, and parents play a significant role in influencing attitudes and beliefs. Teachers can improve attitudes and beliefs about mathematics and statistics through verbal encouragement, technology-enhanced instruction, projects that use real or student-generated data, and, as will be further established next, service-learning.

Service-learning and Statistics

Service-learning has been applied in mathematics predominantly in some form of a statistics project. Perhaps the most extensive of these examples is that of Root and

Thorme (2001), whose model was utilized extensively in designing the service-learning project in this study. Within this model, college-levels students in an elementary statistics course define a driving research question and design and implement a study. Students choose between working directly with a community agency or on their own. The community projects fall into one of four categories based on the needs of the community agency, referred to as the client. Students may be required to create an original study and collect their own data, collect data for a study that has already been designed by the client, analyze data previously collected by the client, or analyze relevant and available data from an outside source like a public office or the Internet. Students are assessed based on project reports, journals, and teamwork.

According to course evaluations, those who choose to participate did so from a desire to help make a difference in the community. By establishing the social relevance of statistics, these students demonstrated an increase in motivation and engagement in learning statistics, reporting that the community-based project provided a valuable learning experience (Root & Thorme, 2001; Thorme & Root, 2002).

Evangelopoulos, Sidorova, and Riolli (2003) conducted a longitudinal study involving undergraduate students in six different sections of a business statistics course taught by three different teachers. Students were given the choice of carrying out a service-learning project or a different research project of interest. Using path analysis and analysis of covariance, they tested five propositions: 1) perceived ease of course will have direct positive effect on perceived usefulness of the course, 2) perceived usefulness and perceived ease of the course will have direct positive effect on favorable attitudes, 3) favorable attitudes will have direct positive effect or intentions to use material in the

future, 4) perceived usefulness will have direct positive effect on intentions to use course material in the future, and 5) participation in service-learning projects will have a positive effect on the perceived usefulness of course material. All five propositions were confirmed in the study.

It is difficult to find studies that compare service-learning projects with research projects that share similar characteristics. The study by Evangelopoulos, Sidorova, and Riolli (2003) provides evidence of the benefit of service-learning projects in statistics versus other kinds of statistics projects also involving real-world data. "The fact that somebody *cared* to receive outcomes of their course material in a real-world setting made a difference for the service-learning participants, and convinced them that the course material was more *useful* than what they would otherwise think" (Evangelopoulos, Sidorova, & Riolli, 2003, p.22). The study also provides supporting evidence that service-learning can influence beliefs about statistics, although it only considers one such belief, namely, perception of usefulness. The authors also point out that the service-learning projects in this study fell short of widely accepted guidelines for service-learning with regard to reciprocity and reflection, but instead, simulated the service-learning experience in the best way possible given practical difficulties.

Duke (1999) incorporated service-learning in an introductory undergraduate statistics course through a project in which students prepared a booklet for The United Way. The booklet contained raw data transformed into charts and graphs and provided updated information regarding fund-raising initiatives. Student surveys indicated that students learned how statistics relates to real life, how to generate charts and graphs using technology, and how to research and organize data. Though students indicated frustration

about learning to work around other peoples' schedules, more than 70 percent of the students found the project worthwhile.

Cushner (2003) engaged an introductory high school statistics class in a service-learning project in which students analyzed the budget for a non-profit organization whose mission is to help at-risk youth. The students applied skills from multiple disciplines including problem-solving, budgeting and finance, statistics, social studies, writing, and science. Student portfolios, project reports, and course evaluations showed improvements in students' attitudes toward statistics, perceived usefulness of mathematics, and in academics.

Similarly, Truran and Arnold (2002) used consulting in an introductory applied statistics course to provide services to a community radio station in the process of conducting an analysis of its listeners. According to course evaluations, through participation in the project, students were more committed and motivated in the course and "more willing and able to reflect on statistical ideas" (Truran & Arnold, 2002, p. 49).

Anderson and Sunger (1999) used service-learning in an upper level college statistics course through a project that required data analysis and interpretation and was aimed at impacting town planning. Increased levels of student interest and motivation in statistics were noted.

To conclude, these examples demonstrate the potential for service-learning in statistics to have a positive effect on personal and learning outcomes. However, the writings in this area tend to lack a rigorous, theoretically-based research design, and they tend to be consistent with those of practitioners interested in practices, processes and program descriptions rather than in scholarly pursuits (Giles & Eyler, 1994). In addition,

all but one of these examples discusses service-learning- based statistics at the college level; the high-school-aged population is widely understudied.

Relevant Theories

Deweyian Theory

In Chapter 1, the conceptual framework of this study was established answering the question, "What were the objects of study?" An equally important question is, "From what theoretical perspective were these objects studied?" I was interested in knowing not only *what* attitudes and beliefs participants held, but also *how* these attitudes and beliefs came to be. An investigation into the literature on the development of attitudes and beliefs led me to John Dewey's theory of educative experience.

One's attitudes and beliefs are a product of accumulated life experiences (Lester, 2002). Dewey (1938) describes three kinds of experiences - miseducative, noneducative, and educative experiences. Miseducative experiences obstruct the educative potential of future experiences. Noneducative experiences do not necessarily stunt growth, but they do not necessarily foster it either. Noneducative experiences are routine and automatic, like riding the bus to school or tying one's shoelaces. When mathematics is presented in way that promotes rote memorization and mechanical procedures, doing mathematics can become a noneducative or a miseducative experience. The kinds of experiences that Dewey believed schools should aim to provide are educative ones. Educative experiences are thought provoking experiences that arouse curiosity and illuminate connections to previous knowledge and experiences. Dewey believes that the more educative experiences one has, the more likely one is to be able to solve problems encountered in life.

Dewey's (1938) philosophy of educative experience is based on the "belief that all genuine education comes through experience but does not mean that all experiences are genuinely or equally educative" (p.25). An immediately enjoyable experience may, in turn, promote a careless attitude, which could stifle subsequent experiences that might have otherwise been educative. An experience that, while increasing a particular skill, can also automate it to the point which it becomes disengaging. Thus, "the central problem of any education based upon experience is to select experiences that live fruitfully and creatively in subsequent experiences" (Dewey, 1938, p. 28).

Dewey's philosophy of educative experience also forms the theoretical foundation of service-learning (Giles & Eyler, 1994). Dewey suggests the use of projects as a means for producing the educative experience. Dewey's theory applies to service-learning through the four defining criteria of an educative project (as cited in Giles & Eyler, 1994) and are as follows:

> First, it must generate interest. Second, it must be worthwhile intrinsically. Third, it must present problems that awaken new curiosity and create a demand for information. Fourth, it must cover a considerable time span and be capable of fostering development over time. (p. 80)

The first three criteria are clearly linked to the affective domain. Therefore, it is reasonable to anticipate that service-learning projects designed with these criteria in mind would influence attitudes and beliefs.

Dewey's philosophy of educative experience played two central roles in the research design. First, it guided the research by focusing my inquiry into the development of attitudes and beliefs on participants' experiences. Secondly, as the theoretical

foundation of service-learning, it provided an additional rationale for the anticipated influence of service-learning on attitudes and beliefs.

Self-Efficacy Theory

Measuring self-efficacy beliefs.

Self-efficacy is defined as "people's beliefs about their ability to produce designated levels of performance that exercise influence over events that affect their lives" (Bandura, 1994, p. 2). Self-efficacy theory is rooted in a larger theoretical framework called social cognitive theory, founded by Albert Bandura. Social cognitive theory is based on a view of human agency characterized by intentionality, forethought, self-regulation, and self-reflection capabilities that place people in a position to act as both producers and products of their social systems (Bandura, 2001). Human behavior is a product of cognitive, affective, and environmental influences (Bandura, 1989; Pajares, 2002) working together in concert. Central among the thoughts that direct human action, behavior, and emotional reactions are self-efficacy beliefs (Bandura, 1989). Self-efficacy beliefs influence academic motivation, achievement, learning, and career choices (Bandura, Barbaranelli, Caprera, & Pastorelli, 2001; Schunk, 1991; Schunk & Pajares, 2002; Stevens, Olivarez, Jr., Lan, & Tallent-Runnels, 2004).

Self-efficacy beliefs are related to other motivation constructs, like self-concept and outcome expectancy beliefs, but they are more specific with regard to judgment of capabilities *within a given context* and to accomplish a *specific*, *related goal* (Pajares, 1995, ¶ 9). Therefore, "measures of self-efficacy should be specifically tailored to the criterial task being assessed and the domain of functioning being analyzed" (Pajares & Miller, 1995, p. 190). However, the tendency in educational research has been to use

generalized measures of self-efficacy to predict outcomes, which has resulted in "confounding relationships" and "ambiguous findings" (Pajares & Miller, 1995, p. 190).

Recent mathematics research has heeded the call to match self-efficacy and outcome assessments. For example, Finney and Schraw (2003) developed two measures of statistics self-efficacy, current statistics self-efficacy (CSSE) and self-efficacy to learn statistics (SELS). These measures were used to verify that statistics self-efficacy is a good predictor of performance, but on a task specific level (e.g. computing variance) versus a global level (e.g. learning statistics). Similarly, Pajares and Miller (1995) compared mathematics self-efficacy beliefs with two outcomes: ability to solve math problems and math-relatedness of academic major. Based on these outcomes of interest, three matching measures of confidence were used: confidence in capability to solve the math problems relevant to the outcome assessment, confidence to succeed in math-related courses, and confidence to perform math-related tasks.

The previous example illustrates how, by clarifying exactly what the confidence is in regard to, self-efficacy can be measured in terms of confidence. Global confidence in mathematics ability, for instance, is not an appropriate measure of mathematics self-efficacy, because of the situation-specific defining nature of self-efficacy (Pajares & Miller, 1995). One may maintain low confidence in mathematics in general, but have efficacious beliefs with regard to basic computational skills like adding and subtracting integers. Bandura (1997) explains, "Confidence is a nondescript term that refers to strength of belief but does not necessarily specify what the certainty is about" (p. 382). Therefore, assessing self-efficacy in terms of confidence should be done cautiously, taking care to specify the object of confidence, particularly when it is being used as a predictor of an outcome.

Comparing self-efficacy beliefs with a specified outcome was not a purpose of this study, however, one of the objects of study was a self-efficacy belief, namely, confidence in ability to do mathematics. The reason why this judgment of confidence can be considered a measure of self-efficacy is because each participant was asked to first explain what it means to *do* mathematics. Then, judgments of confidence referenced this specific concept. Should an extension of this study be carried out to compare these self-efficacy beliefs with an outcome, the outcome should be assessed in terms of participants' individual notions of what it means to *do* mathematics. Though in some cases, responses may be too general to define appropriate criterial tasks. This issue, while valid, is not of concern within this study. Rather, the significance of this discussion of measures of self-efficacy and confidence is to provide a rationale for the use of self-efficacy theory in the framework of this study. Self-efficacy theory has important implications regarding sources and the development of self-beliefs, and it played a key role in data analysis.

Sources of self-efficacy.

Judgments of capabilities to achieve designated results come from four main sources. The most effective way to build a strong sense of self-efficacy is through performance mastery experiences (Bandura, 1989, 1994).

> If people experience only easy successes they come to expect quick results and are easily discouraged by failure. A resilient sense of self-efficacy requires experiences in overcoming obstacles through perseverant effort. Some setbacks and difficulties in human pursuits serve a useful purpose in teaching that success usually requires sustained effort. (Bandura, 1994, p.2)

The real and multidimensional context of service-learning requires that students persistently grapple with complex issues that may not have clear answers, thus providing an ideal setting to build mastery experiences.

A second source of self-efficacy beliefs is through vicarious experiences of social models (Bandura, 1994). When people see others that are similar to them succeeding at a particular task, it can raise the belief in their own ability to succeed at a comparable task. On the other hand, seeing someone believed to have similar capabilities as one fail at a task can lower self-efficacy beliefs. The key factor that links the strength of the vicarious experience in influencing self-efficacy beliefs is the degree of similarity believed between the observer and the observed (Bandura, 1994; Pajares, 1997).

Self-efficacy beliefs can be strengthened by verbal and social persuasion that boosts one's confidence to succeed at a given task. However, positive verbal persuasion alone may not be enough to change inefficacious beliefs to efficacious ones. Experiences in failure can quickly discredit persuasion of others to engage in challenging activities. It is easier to undermine efficacious beliefs and to dissuade one from a belief in their ability to achieve a task (Bandura, 1994).

A fourth source of self-efficacy beliefs is emotional and physiological states like anxiety, stress, fatigue, mood, and fear (Pajares, 1997). People's physiological states are interpreted as signs of vulnerability or physical debility and therefore, can enhance or worsen a sense of self-efficacy (Bandura, 1994).

Developing academic self-efficacy.

Young children do not have a sense of their own capabilities and need adult supervision to keep them out of harm's way. As children grow to develop cognitive and

self-reflective capabilities, self-efficacy judgment starts to dominate external regulation (Bandura, 1989). With regard to judgment of capabilities to perform academic tasks, self-efficacy develops through influences from family, peers, the school environment, and through transitions in schooling (Bandura, 1994, Schunk & Pajares, 2002).

Initial sources of efficacy come from family. Parents who provide stimulating and exploratory environments for their children also produce opportunities for efficacious actions (Bandura, 1994). When home environments contain materials that stimulate curiosity and encourage learning, they provide varied opportunities for building mastery experiences and thus, promote efficacious beliefs (Schunk & Pajares, 2002).

Home environments also provide children with first opportunities for vicarious experiences and social persuasion. Parents can build efficacious beliefs when they model persistence and sustained effort in the face of challenge and by encouraging and supporting their children in their efforts to do the same (Schunk & Pajares, 2002).

As children get older, peers play an increasing role in developing self-efficacy beliefs. Vicarious experiences become especially influential in efficacy development as children see others that are similar to them succeed or fail at various tasks (Bandura, 1989). Once schooling begins, students tend to group themselves together in networks of similar peers. These peer networks serve as a powerful mechanism for either building or destabilizing efficacious beliefs (Schunk & Pajares, 2002).

School plays a critical role in the development of cognitive competencies and sense of academic self-efficacy. “Many social factors, apart from the formal instruction, such as peer modeling of cognitive skills, social comparison with the performances of

other students, motivational enhancement through goals and positive incentives, and teachers' interpretations of children's successes and failures in ways that reflect favorably or unfavorably on their ability also affect children's judgments of their intellectual efficacy" (Bandura, 1994, p. 11). In addition, if school systems work to instill a belief among its teachers that they are capable of promoting academic success, teachers can develop a positive sense of instructional self-efficacy. In turn, this helps teachers to create a classroom environment conducive to the development of students' cognitive competence (Bandura, 1994).

On the other hand, there are school related factors that can lower students' sense of academic self-efficacy. For example, ability grouping, otherwise known as tracking, can worsen academic self-efficacy for students grouped with lower achieving students, as can classrooms that allow for excessive social comparisons (Schunk & Pajares, 2002).

Finally, transition in schooling affects academic self-efficacy. Because elementary aged students are with the same teacher and peers throughout most of the school day, they receive more individual attention, but when they transition to middle school, they change classes and teachers. "The widely expanded social reference group, coupled with the shift in evaluation standards, requires that students reassess their academic abilities" (Schunk & Pajares, 2002, p. 8), and as a result, academic self-efficacy can suffer in areas like mathematics (Ma, 2003).

To summarize, self-efficacy theory is rooted in Bandura's (1986) social cognitive theory, which views humans as agents of their own behavior through evaluations of interactions with their environment and of cognitive and affective factors. Pervasive throughout these evaluations are judgments of capabilities to achieve specific outcomes,

that is, self-efficacy beliefs. Self-efficacy beliefs are different from other motivation constructs because judgments of ability are more contextual and reference a specific goal or task. Thus, it is only appropriate to use confidence as a measure of self-efficacy if the object of confidence is explicit. Further, if self-efficacy beliefs are measured for the purpose of predicting an outcome, the measure of self-efficacy should precisely match the outcome it is intended to predict.

The four main sources of self-efficacy beliefs are performance mastery experiences, vicarious experiences, social persuasion, and emotional and physiological states, with mastery experiences having the greatest influence. Academic self-efficacy develops through familial and peer influences as well as through schooling and transitions in schooling. There are factors among all of these developmental sources that can either enhance or worsen a sense of academic self-efficacy.

CHAPTER 3

METHODOLOGY

Rational for Teacher-Research

The study was conducted using interpretivist, action research methodology. Whereas the goal of traditional social science research is to conduct inquiry without disturbing the research setting, action research is interventionist in nature (Herr and Anderson, 2005; Travis, 1999). For this reason, action research methodology is well suited for research aiming to diagnose and remedy problems in schools and classrooms and for studying innovative approaches to teaching and learning (Nickson, 1992).

According to Herr and Anderson (2005, pg. 3), action research is "inquiry that is done by or with insiders to an organization or community, but never to or on them." This definition allows for variation in researcher positionality. Herr and Anderson (2005) describe a continuum that on one end, positions the researcher as an outsider, collaborating with insiders, in order to create some form of change within an organization. On the other end, and as in the case of this study, the researcher may actually be a practitioner within the organization. In the field of education, the participatory nature of action research allows for the direct involvement of teachers in such a way that teachers can conduct research in their own classrooms and schools (Nickson, 1992). In other words, teacher research, which Cochran-Smith and Lytle (1993,

p. 27) define as "systematic and intentional inquiry carried out by teachers in their own school and classroom settings," is one form of action research.

Feldman and Minstrell (2000) describe the two main purposes of teacher research. The first purpose is to improve teachers' teaching practices and ultimately students' learning. That is, teacher research generates *local knowledge*, or knowledge consumed by teachers and their immediate communities (Lytle & Cochran-Smith, 1992). The second purpose of teacher research is to assist teachers in developing an understanding of their surrounding educational situations so they can contribute to the body of knowledge pertaining to teaching and learning in their field. In other words, teacher research also generates *public knowledge*, or knowledge that is useful to the greater community and to universities (Lytle & Cochran-Smith, 1992).

By and large, the importance of teacher research as a means for producing local knowledge is undisputed (Cochran-Smith, 2005). However, teacher research has struggled for recognition in the larger academic arena as a means for producing public knowledge. Much of this dispute has centered on the issue of generalizablity of teacher research, a dispute rooted largely in paradigmatic conflict. Under a positivist paradigm, generalizability can only occur through objectivity, and objectivity is neither achievable nor desired in immersive, insider research. But research about teaching and learning generated exclusively by outsiders is perceived by many teachers as lacking grounding in relevant classroom experience and is therefore, sometimes not viewed as useful (Herr and Anderson, 2005). Instead, like other forms of interpretive research, teacher research is a "bottom-up" approach to knowledge generation. That is, research questions emanate from everyday experiences of teachers within the contexts of actual classrooms.

Generalizability and objectivity are no longer of interest. Rather, subjectivity is embraced and unveiled, and emic insights into particular classrooms are woven together to create a rich, dynamic blanket of knowledge about teaching and learning.

Cochran-Smith and Lytle (1999) view teacher research as a means "to link teaching and curriculum to wider political and social issues" in such a way that "creates dissonance, calling attention to the constraints of the hierarchical arrangements of schools and universities as well as to the contradictions of imperatives for both excellence and equity" (p. 22). In this light, teacher research is a powerful means for generating both local and public knowledge.

In the academic arena, the primary source of discomfort in recognition of teacher research beyond a source of local knowledge stems from the practice- versus theory-driven nature of this kind of research (Herr and Anderson, 2005), though an additional argument concerns the rigor of teacher research. Cochran-Smith and Lytle (1999) refer to this as the 'methods critique.' Some teachers may not have adequate training in research methodology and therefore, may lack the skills to design and carry out a rigorous study. In addition, while being an insider has its advantages, there may be important aspects of the teacher's practices or the research setting that get overlooked because the teacher takes them for granted (Ball, 2000). In order to avoid these potential downfalls in teacher research, it is advantageous for the teacher-researcher to collaborate with other teachers and researchers when possible. Perhaps the best-case scenario results when a teacher, well trained in research methods, collaborates with a team of university researchers to conduct a systematic, rigorous study (Herr and Anderson, 2005). As the teacher researcher movement continues to gain momentum, collaborative teacher/university

researcher studies are receiving recognition through such avenues as scholarly journals (see Harthun, Drapeau, Dustman, & Marsiglia, 2002; Torrance & Pryor, 2001) and dissertations (see Bartoli, 2003; Dosemagan, 2004; Hogewood, 2004; Ranker, 2004).

The Research Paradigm

A paradigm is a worldview or a set of beliefs that defines how a researcher decides what is important and valid for documentation. Depending on research questions, personal beliefs, and research constraints, researchers claim a certain paradigm or perhaps a synthesis of several paradigms (LeCompte & Schensul, 1999b). The research paradigm is used to determine such things as the significance of research questions, research methods, research reporting styles, and the importance and implications of the research (Ernest, 1998).

Why An Interpretivist Research Paradigm?

There is a lack of consensus regarding the way in which to describe the paradigm associated with action research. Nickson (1992) argues that action research is characteristic of both the positivist and interpretivist paradigms because it relies on both observational and behavioral data. Travis (1999) refers to action research as an interpretivist method, distinguishable from other interpretivist methods by its interventionist nature. Still other researchers describe action research as a paradigm in its own right (Akdere, 2003; Doerr & Tinto, 2000) referencing *the* action research paradigm. For example, Kilpatrick (as cited in Nickson, 1992) describes action research as one of three approaches to educational research, the other two being behaviorist (positivist) and interpretivist:

> The behaviorist stands apart from an educational encounter, aiming at general laws that will transcend time, place and circumstance. The interpretivist moves into that encounter, attempting to describe and explain it from a nonjudgmental stance. The action researcher enters the encounter with an eye toward obtaining greater freedom and autonomy for the participants. (p 98)

However, this description is not to imply compartmentalization of each approach. Rather, "research is moving along a spectrum of activity from a position where the individual *acts* of teachers and pupils are studied, to a holistic approach where all teacher-pupil and pupil-pupil *interactions* are scrutinized together with the values, beliefs, and attitudes they bring to the situation" (Nickson, 1992, p. 105). With this spectrum in mind, my research paradigm most closely aligns with the interpretivist research paradigm.

The interpretivist research paradigm is also referred to under a variety of names such as the qualitative, naturalistic, constructivist, or alternative research paradigm (Ernest, 1998; LeCompte & Schensul, 1999b). Within the literature, these terms are used interchangeably, though they have origins in different disciplines (LeCompte & Schensul, 1999b). In mathematics education, research has shifted from a predominantly positivist, quantitative paradigm perspective to that of the interpretivist paradigm (Ernest, 1998). In addition, as teachers are becoming more involved in research activities through action research, either by collaborating with university researchers or by becoming teacher researchers, the use of descriptive, interpretivist methodologies in educational research in general is becoming more common (Nickson, 1992).

Philosophical Claims of Interpretive Research

Every paradigm of inquiry carries three underlying philosophical claims that determine what constitutes legitimate inquiry. The first is an ontological claim or theory

of reality, the second is an epistemological claim or theory of knowledge and knowing, and the third is a methodological claim or theory of inquiry. Each claim is both interconnected with and constrained by the other two (Guba & Lincoln, 1994).

The interpretive research paradigm is concerned with human understanding, interpretation, and lived truth, in human terms (Ernest, 1998). "Interpretivists believe that what people know and believe to be true about the world is constructed – or made up – as people interact with one another over time in specific social settings" (LeCompte & Schensul, 1999b). In other words, the ontological claim of an interpretivist is that reality is relative, local, and specifically constructed and that every construct carries equal importance (Guba & Lincoln, 1994; LeCompte & Schensul, 1999b).

The epistemological claim of an interpretivist is that the researcher and the researched are interactively linked and that knowledge claims are subjective (Guba & Lincoln, 1994). Interpretive research is value-laden. Interpretivists define "shared constructs and meaning as "situated"; that is, they are located in or affected by the social, political, cultural, economic, ethnic, age, gender, and other contextual characteristics of those who espouse them" (LeCompte & Schensul, 1999b, p. 49). Under this claim, it is neither possible nor desirable to eliminate bias. Instead, values have "pride and place" (Guba & Lincoln, 1994, p. 114) and measures should be taken to openly explain the role of bias in the interpretation of findings.

Finally, these ontological and epistemological claims lead to methodological claims. Before elaborating, it is important to note the difference between *method* and *methodology*. Ernest (1997) explains:

> Educational-research *methods* are specific and concrete approaches. In contrast, education-research *methodology* is a *theory* of methods – the underlying theoretical framework and the set of epistemological (and ontological) assumptions that determine a way of viewing the world and, hence, that underpin the choice of research methods. (p. 35)

While the general tendency is to employ quantitative methods within a positivist paradigm and qualitative methods within an interpretivist paradigm, the point that Ernest makes is that the methodology of a paradigm is not necessarily exclusive of particular methods. While methodology may influence methods, methods should be selected that most appropriately address the research questions.

The methodological claim of an interpretivist is that "authentic or valid individual constructs or ideas can be elicited and refined only through interaction between and among all researchers, participants, and partners in the project" (LeCompte & Schensul, 1999b, p. 50). In this study, because of my interpretivist worldview, but also because of the nature of the research questions, qualitative methods were exclusively applied.

The research paradigm associated with any study is a critical factor in the research design. Among the components of the research design impacted by the research paradigm are the criteria used to determine the quality of the research. Lincoln and Guba (1985) define four quality criteria for interpretivist research that, together, constitute the "trustworthiness" of the research. These criteria are defined next, along with a description of how each criterion was met in this study.

Meeting Trustworthiness Criteria

The trustworthiness of research concerns the extent to which the research findings are worthy of attention. In quantitative research, worthiness of the research is assessed according to constructs known as internal and external validity and reliability. The

researcher takes an objectivist stance. Lincoln and Guba (1985) argue that there are more appropriate criteria for judging the worthiness of interpretive or qualitative research. The parallel to internal validity in interpretive or qualitative research is what they call "credibility". External validity is paralleled by "transferability", reliability by "dependability", and objectivity by "confirmability".

Credibility refers to the degree to which the researcher's interpretations are consistent with the ideas and meanings intended by the participants. Transferability refers to the extent to which the research findings transfer to other contexts or populations. The reader is responsible for judging the applicability of the findings to the receiving context. Therefore, the researcher is responsible for providing sufficient detail to enable the reader to determine relevance. Dependability refers to the extent that, if study were conducted again in a similar context with similar participants, the findings would be the same. It refers to the stability and the traceability of the data. Confirmability refers to the extent to which the findings are rooted in a logical process of inquiry and are not just reflections of the researcher's ideas. In other words, to what extent can the findings be confirmed?

Lincoln and Guba (1985) suggest several strategies for achieving each of the four trustworthiness criteria. To achieve credibility, prolonged engagement, persistent observation, triangulation, and member checks are among the strategies. Prolonged engagement means spending enough time in the field to become oriented to the situation and to build trusts with participants in order to be certain to fully understand and appreciate the context. Through persistent observation, the goal is to focus the inquiry on the elements of the situation that most directly apply to the purpose of the study.

Triangulation can refer to multiple methods, sources, or investigators. Member checks, verification of researcher interpretations with participants, are crucial in establishing credibility. "If the investigator is to be able to purport that his or her reconstructions are recognizable to audience members as adequate representations of their own (and multiple) realities, it is essential that they be given the opportunity to react to them" (Lincoln and Guba, 1985, p. 314).

To achieve transferability, descriptive data that enables an external person to determine whether results transfer to a specific situation is suggested. Lincoln and Guba (1985) use the term "thick description" to describe the type of data required that would allow an outsider to make such a judgment.

Dependability can be established by demonstrating credibility, since there can be no validity without reliability, and through a dependability audit. Likewise, confirmability can be achieved through a confirmability audit. Lincoln and Guba (1985) explain:

> The inquiry auditor examines the *process* of inquiry, and in determining its acceptability the auditor attests to the dependability of the inquiry. The inquiry auditor also examines the product of the data – the data, findings, interpretations, and recommendations – and attests that it is supported by data and is internally coherent so that the "bottom line" may be accepted. This latter process established confirmability of the inquiry. Thus a single audit, properly managed, can be used to determine dependability and confirmability simultaneously. (p. 318)

Finally, reflexive journaling is like a researcher diary and has implications in achieving all four criteria. In particular, the reflexive journal plays a key role in an inquiry audit because, among other things, it helps the auditor to determine the extent to which the researcher's biases influenced findings.

Four strategies were employed to ensure credibility of this study. The first two strategies are prolonged engagement and persistent observation. Before the study formerly commenced, I spent 15 weeks, approximately 75 contact hours, building trust with and getting to know the participants as their first semester mathematics teacher. During the study, I observed and interacted with participants on a daily basis totaling more than 65 hours. The third strategy was triangulation of data sources. Three sources of data were used to create codes and to gather supporting evidence of adequate depth toward findings. Finally, credibility was also established through member checking. Following data collection and initial coding, I met with participants and discussed my preliminary findings and interpretations with them. Feedback was elicited regarding any misinterpretations or missing pieces of the data.

Dependability of the study was achieved by establishing credibility. Dependability and confirmability of the study was established by creating an audit trail and by undergoing an inquiry audit by two independent scholars. I elicited the help of two competent, well-trained peers to conduct the inquiry audit. I provided them with a trail of raw data, data reduction and process notes, and other research notes. Final audit reports and provided as Appendices A and B that attest to the confirmability, dependability, and credibility of the study.

Transferability of the study was established through thick description. I have strived to provide significant detail and rich description regarding all components of the research design so that the reader can determine the transferability of the findings.

The last strategy applies to all four criteria. I maintained a reflexive journal throughout the research process so that I was aware of my own subjectivity and its

potential to influence the research. In the next chapter, I provide excerpts from my journal that influence or support the findings of the study.

Researcher Subjectivity

In an interpretive investigation, the researcher is a primary instrument of data collection (Merriam, 1998; LeCompte & Schensul, 1999b; Creswell, 2003). As such, it is necessary to acknowledge the bias and subjectivity of the researcher. When openly and honestly revealed, it can add to the richness of the study and thus, enhance the degree of transferability of outcomes (Creswell, 2003). Herr and Anderson (2005) explain:

> As researchers, we acknowledge that we all enter the research with a perspective drawn from our own unique experiences and so we articulate to the best of our ability these perspectives and biases and build a critical reflexivity into the research process. We also articulate these evolving perspectives in our journaling, field notes, and to some extent, in the dissertation itself…so while bias and subjectivity are natural and acceptable in action research, as long as they are critically examined rather than ignored, other mechanisms may need to be put in place to ensure that they do not have a distorting effect on outcomes. (p. 60)

Through reflexive journaling, I made a conscious effort to describe the subjectivity of the research. Beyond what is recorded in my journal, there are certain beliefs that I hold regarding education and personal experiences that are relevant to the study. These are beliefs that I held prior to the start of the study as well as at present. I take a moment now to share these relevant beliefs and experiences.

My Beliefs About Mathematics Education

Benjamin Franklin (1749) once said, "It would be well if (students) could be taught every thing that is useful, and every thing that is ornamental, but art is long, and their time is short. It is therefore proposed that they learn those things that are likely to be most useful and most ornamental." Mathematics is useful. Mathematics is ornamental.

Both the useful and the ornamental serve a purpose in education, each deserving of recognition in their own right. Attempting to disguise the ornamental as useful serves no purpose in education. In other words, I would never try to convince my students that to apply the quadratic formula to a word problem involving the trajectory of a golf ball, for example, is a real world use of mathematics. I do not mean to imply that this kind of problem is useless. Its usefulness rests in the deconstructing of the words and then in reassembling them numerically, algebraically, and conceptually. Granted, as a use of mathematics, this is a harder sell to students. Practical usage like money management and job related applications are more real to students, and should also be included in the curriculum.

Why Service-Learning?

To explain my decision to teach statistics using service-learning, I must first give some insight into my experience in activism. Before I began teaching, roughly seven years ago, I was heavily involved with a non-profit agency whose mission was to raise awareness about various environmental issues and to incite action to address them. The agency worked at a grassroots level and used endurance bicycling events to generate awareness and publicity. One of the rides I participated in was a cross-country event, approximately 2000 miles in eight weeks. On this ride, we met people suffering from the devastating effects to health of toxic waste spills left inadequately cleaned up in their community. We met with community leaders, spoke at public hearings, and held press releases in an effort to urge officials to address the needs of these people and their community. It was intensely hard work, but it was also incredibly rewarding.

At the same time, I was nearing the completion of my master's degree in mathematics. While my work as an activist was fulfilling in many ways, I made the decision to pursue another passion, a career as a mathematics educator. My belief in the importance of activism and the power of service carried with me into the classroom. My goal as a teacher is to empower my students to make a difference in the world. I want my students to be caring and responsible citizens. Mathematics can assist them in becoming agents of social change by helping them to become critical thinkers. More specifically, mathematics can help them to make logical, supported arguments and generalizations, to think creatively, to make informed decisions, to approach ill-defined problems and propose viable solutions to them, and to anticipate outcomes. Service-learning is a method that can help me to achieve my goal as a mathematics educator - to enable my students to learn and use mathematics in practical and empowering ways while also helping them develop as socially responsible beings.

Context

Participants

The participants in this study were 11 students in my introductory, high school, service-learning-based statistics class. The participants ranged in age from 17 to 18 years. There were seven female participants whose pseudonyms are Mary, Lisa, Kelly, Carrie, Angie, Paula, and Dana, and four male participants whose pseudonyms are Sam, Eric, Brad, and Adam. Kelly, Angie, and Adam were in the 12th grade and the others were in the 11th grade. Participants' previous high school math courses included the equivalent of an Algebra 2 course, as well as a course in Geometry and Trigonometry.

Participants were selected using purposeful sampling (Merriam, 1998) since the objective was to "discover, understand, and gain insight" (p. 61) into attitudes and beliefs of high school students in a service-learning-based statistics course. At the time of the study, I was teaching three other freshmen algebra courses and only one service-learning-based functions and statistics course. Therefore, the type of sampling used was criterion-based, the criterion being that participants must be high school students taking a first course in statistics. All willing participants in the class were included in the study. All but one chose to participate.

Before the start of the study, I explained to my students that I was going to be conducting a research project and I would be asking them to voluntarily participate in it. Because the students were minors, in order to participate it was necessary to receive both consent from a parent or guardian and assent from the minor. Appropriate forms were distributed (see Appendix C and Appendix D) and collected in sealed envelopes. The forms explained that these envelopes would not be opened until the course grades had been submitted at the close of the course. This was to ensure that the decision to participate in the study would not result in any differential treatment. The forms also explained that participation in the study would not entail any additional work beyond required coursework. That is, the data that would be used for the study - weekly journals, narratives, and open-ended surveys - were part of regular required coursework. Understanding my students' attitudes and beliefs regarding statistics helps me to meet their needs better as a teacher (Finney & Schraw, 2003; Lester, 2002). Therefore, this data served an important purpose to me in my role as teacher, aside from my role as researcher.

The School and its Culture

The participants in this study were enrolled in an affluent, nonsectarian private school in a large, southeastern city. At the time of the study, the school was 33 years old. The student body consists of approximately 915 students ages 3 - 18. The school actively recruits students from a racial, cultural, and socioeconomic cross-section of the community; students of color consist of 25% of the population. Roughly 12% percent of the student body receives some form of financial aid. The high school student to teacher ratio is approximately 12:1.

Parent involvement plays an integral role in the school's operations. Students refer to teachers on a first name basis in an effort to create a more comfortable environment. Many classrooms utilize sofas as well as tables for student work areas to create an inviting and comfortable atmosphere. There are no bells that ring to signal the changing of classes because teachers and students are trusted to follow a set schedule. Emphasis is placed on getting to know students on an individual basis. Individuality is encouraged and celebrated. Students of all races, religious affiliations, and sexual orientations are welcomed and recruited. The school places great value on developing students as socially and environmentally responsible, empathetic individuals while maintaining high standards of academic excellence.

While atypical in the public school system, in many independent schools, community service is part of the school culture. A survey conducted by The National Association of Independent Schools (NAIS) found that 87.5% of independent schools have a community service or a service-learning program (NAIS, 2001). The NAIS survey also indicated that as these programs have grown, many independent schools have

responded by hiring Community Service Coordinators to manage and direct service projects. Such was this case for this school.

Two years prior to this study, the school hired Ms. Laura Davidson (pseudonym) as Director of Service Learning and Civic Involvement. The impetus behind Ms. Davidson's job was that as school has grown, it has become more challenging to manage service projects across the grade levels. Several of her goals were to increase the level of intentionality of how the school uses service for learning, to increase the number and complexity of service-learning projects, to provide teachers with assistance and tools for designing service-learning projects, to cultivate and maintain relationships with community agencies, and to coach teachers and students on service-learning project management. Up until Ms. Davidson came to the school, service was typically an activity that stood apart from classroom activities. In the high school, most service was done outside of classes through clubs or individual initiatives without any direct link to academics. Therefore, service-learning as defined in this paper, was not a common practice in the high school. Furthermore, service-learning was not practiced at all in any mathematics courses. So, while participants had engaged in other forms of service prior this course, the extent to which the service qualified as "service-learning" by definition, varied. Also, none of the participants had ever experienced service-learning in the context of mathematics.

The Course

The course was called Functions and Statistics. It met every day for 45 – 50 minutes, depending on the day. The objective of the course was to review and solidify basic concepts in algebra and statistics. Within the mathematics curriculum at this

particular school, the course was one of a series of courses that moves at a slightly slower pace than other typical mathematics courses. The pace of the course and the extent of the material covered depend on the time required for students to master material. Students were placed in the course because previous teachers, parents, and the students themselves determined that it would be beneficial to have extra time to practice and absorb concepts before moving on. While this kind of placement resembles what is considered "tracking," one important difference is that the curriculum allows for movement between courses from year to year, and in some cases, during the year. The philosophy is that each student has individual needs that change and develop at a unique pace. Therefore, the school has done its best to design a flexible curriculum that caters to these individual needs and interests and deemphasizes academic competition. Nonetheless, there is still an unavoidable stigma of a slower-paced course, though its overall impact on students seems to be minimal. And, as the data will reveal, in some cases, this stigma played an influential role in this study.

The study began at the start of the second semester of the school year, with 13 weeks remaining in the course. Students had completed the algebra/functions portion of the course and were just beginning the study of statistics. At this point, students had completed a substantial review of Algebra 2 topics and numerous practice SAT-type problems. As the course shifted focus to topics in statistics, a new textbook was adopted for the remainder of the course. The primary textbook used was the fifth edition of *Statistics: Concepts and Controversies,* by David Moore (2001). This book was chosen because of its ease of reading and its de-emphasis on heavy statistical analysis, focusing

more on descriptive statistics. Supplemental materials were used for the probability section and other various topics.

Course requirements included regular homework and class work assignments, daily participation in class discussions, weekly journals, three exams, and the service-learning project. Homework, journals, and participation each counted as 10% of the course grade, while exams and the project counted for 35% each. Details of the service-learning project and its components follow.

The Service-Learning Project

This was not the first time that I had implemented service-learning in one of my courses. The previous year, I taught Functions and Statistics through service-learning as well. That year, my class partnered with four different community agencies on four different analysis projects. This model proved overly difficult to manage and I decided that the next project would only involve one agency.

The project was designed according to the 10 principles of good practice for service-learning. The outcome of a conference sponsored by The Johnson Foundation, these principles are the result of consultations conducted by the National Society for Experiential Education with more than 70 service-learning organizations. In the conference report, Porter-Honnet and Poulson (1989) state that good service-learning:

1. Engages people in responsible and challenging actions for the common good.
2. Provides structured opportunities for people to reflect critically on their service experience.
3. Articulates clear service and learning goals for everyone involved.
4. Allows for those with needs to define those needs.
5. Clarifies the responsibilities of each person and organization involved.
6. Matches service providers and service needs through a process that recognizes changing circumstances.
7. Expects genuine, active, and sustained organizational commitment.

8. Includes training, supervision, monitoring, support, recognition, and evaluation to meet service and learning goals.
9. Insures that the time commitment for service and learning is flexible, appropriate, and in the best interests of all involved.
10. Is committed to program participation by and with diverse populations. (¶ 8)

With these principles in mind, I began the task of identifying an agency that would partner with my statistics class.

Identifying a community partner.

In the months leading up to the second semester I worked with Ms. Davidson to identify an agency within the community that would like to partner with my statistics class on a service-learning project. Ms. Davidson compiled a list of agencies that either she or the school had developed partnership relationships with in the past. From this list, Ms. Davidson and I determined the agencies that were likely to meet two essential criteria. First, the agency must have a need for statistical consulting services. Second, the agency must have adequate human and material resources needed to sustain the project over 13 weeks.

An email was then sent out to the executive directors of these agencies including an attachment summarizing the goal of the project, the structure and components of the project, the way in which the project fits in with the course, the roles of the agency, students, and teacher, and a tentative timeline for the project. This summary is provided as Appendix E. Once responses were received from interested agencies, I made follow up phone calls to discuss the project in greater detail. Based on these conversations, I determined that one agency met both of the essential criteria.

This agency serves the community by helping refugees (persons who have fled their country from persecution, war, or natural disaster) to reestablish themselves within the surrounding community. The agency offers assistance to refugees by providing material and physical needs like food, shelter, and medical attention, helping refugees find employment, and providing education, training, translating, and counseling services. The agency is funded in part by the federal government but relies heavily on grants, donations, and volunteers. I was pleased when this agency agreed to partner with my statistics class. Throughout the rest of this paper, I refer to this community partner as "The Agency".

Planning the project.

Ms. Davidson and I met with the Associate Director of The Agency to discuss a plan for the project. We generated an outline for facilitating the project (Appendix F). We decided to build the project around an evaluation of three different donation collection programs. Students would divide into three teams of four. The first program involved placing collection bins in various locations in the community. Bins were labeled with signs requesting specific items that refugees needed the most. This program was called Lighten the Load. The second program would entail raising money to shop at yard sales and thrift stores for items on a wish list generated by the agency. The students eventually named this program Project Yard Sale.

The idea for the Lighten the Load program came from the agency but had not yet been implemented at the start of the course. The second program was generated from discussions between Ms. Davidson, the agency, and me. We agreed that the students should generate the third program in order to give them an added sense of ownership of

the project. During the first week of the course, the students brainstormed ideas for the third program and decided to hold a school wide bake sale/swap. Members of the school community could bring in items from the wish list in exchange for baked goods or purchase baked goods. The money raised from the bake sale would go toward funding Project Yard Sale. Students named this program Operation Bake Swap.

Project components.

There were three main project components. Students were required to keep weekly journals, write three project reports, and participate in a minimum of three hours of service with the participating agency. The first project report was a formal evaluation plan for each team's program (Appendix G). The evaluation plan was the cornerstone of the service-learning project. Students were required to write up the background, purposes, research questions, instrumentation, limitations, etc., all components of a real research proposal, for the team's program. Next, students carried out their program and logged data pertaining to donations according to quantity and quality. They also kept track of associated costs of their program. The second report was a status report (see Reeves, n.d. b) of the program's progress (Appendix H). The final report was a formal evaluation of the program based upon the data analysis (Appendix I). Students worked with excel spreadsheets and were required to generate tables displaying categorical and quantitative data for the results and conclusions sections of the final report. Students presented each final report to agency representatives in class.

The service requirement of the project was included in order to provide students with a meaningful context in which to situate the project. Students served after school by organizing the clothes closet at the agency site and by visiting with refugee families. A

case worker was present during visits to translate. Two students were not able to schedule service time and were allowed to complete an alternate project that required a paper on a refugee issue and an advocacy activity.

Data Collection and Rationale

The theory and literature reviewed earlier provide the basis for the methodological procedures selected for this study. What follows is a description of each data collection instrument along with a rationale for its design and use as derived from the literature.

Survey of Mathematical and Statistical Affect (SMSA)

The SMSA is a 17-item open-ended, sentence completion survey designed for this study according to recommendations by Gal and Ginsburg (1994). The SMSA was used, in part, to determine students' attitudes toward mathematics and statistics, general beliefs about the nature and utilization of mathematics and statistics, beliefs about doing mathematics and statistics, and beliefs about confidence in doing mathematics and statistics (see Table 2). It was administered at the beginning and the end of the course.

The first eight items of the SMSA refer to attitudes and beliefs regarding mathematics. The remaining items refer to attitudes and beliefs regarding statistics. Items referring to statistics use slightly different wording on the SMSA given before the course versus after the course, out of necessity. Before the course, items 11 and 12 ask participants what statistics topics they *think* they will like or dislike whereas after the course, participants are asked to identify what statistics topic they *have determined* they like or dislike. Similarly, before the course, item 17 asks participants to judge confidence in ability to *learn to* perform statistical tasks. After the course, this question asks

participants to judge confidence to actually perform statistical tasks. These modifications are consistent with recommendations for assessing statistics self-efficacy according to Finney and Schraw (2003). See Appendix J for the complete survey.

Table 2

SMSA Sample Items

Construct	Sample Item
Attitudes Toward Mathematics/Statistics	I *like* mathematics that involves… (What topics? What skills? Write "not at all" if you so feel so) because…
General Beliefs about Mathematics/Statistics	Statistics is about … (What topics? What skills?)
Beliefs About What it Means to Do Mathematics/Statistics	What I envision myself doing statistics, I see myself (doing what?)…
Beliefs About Confidence in Doing Mathematics/Statistics	In math, I'm really confident that I can do …(What topics? What skill? Write "not at all" if you so feel so) but I'm not as confident that I can do… (What topics? What skill? Write "not at all" if you so feel so)

The SMSA includes questions about both mathematical and statistical affect because one of the sources of statistics-related attitudes and beliefs is mathematics-related attitudes and beliefs (Gal, Ginsburg, & Schau, 1997; Mills, 2004). Further, the SMSA is designed using open-ended questions because the exclusive use of likert-type scales does not allow students to "explain what feelings, attitudes, expectations, or beliefs underlie their responses to a likert-scale, describe the intensity and frequency of

emotional responses, and elaborate on the their sources or causes" (Gal, Ginsburg, & Schau, 1997, ¶ 14).

Narratives

In alignment with Dewey's (1938) philosophy of educative experience, is the notion that attitudes and beliefs are shaped by experiences that promote or stifle growth (Lester, 2002). According to self-efficacy theory, academic self-efficacy is developed as a result of familial and peer influence and experiences and transitions in schooling (Schunk & Pajares, 2002). Similarly, attitudes and beliefs regarding mathematics and statistics are shaped by experiences both within and outside of the school environment (Gal, Ginsburg, & Schau, 1997; Lester, 2002). Written narratives provide insight into participants' experiences that participants perceive to have influenced confidence, attitudes, and other beliefs related to mathematics and statistics. At the beginning of the course, participants are asked to write a narrative response to the following:

> I am interested in understanding what factors have influenced your confidence to *do* mathematics. Please start by explaining what it means to you to *do* mathematics. Then describe how you believe your experiences, both inside and outside of school, have caused you to feel more or less confident in doing mathematics. Go back as far as you feel is relevant. Don't spend time worrying about grammar. Detail and description is more important.

At the end of the year, participants are asked to respond in the same way, except that the term "mathematics" is replaced with "statistics." The intent is to examine the differences and similarities between participants' perceptions of mathematics- versus statistics-related experiences and the role of service-learning in influencing attitudes and beliefs regarding statistics. Intentionally, there is no mention of service-learning in the second part of this task to minimize bias in students' responses.

Student Journals

A third source of data came from student journals. The benefit of using journals is the ease and flexibility in structuring questions in order to more deeply examine the phenomenon of interest. Creswell (1998) describes the qualitative data collection circle as "a series of interrelated activities aimed at gathering good information to answer emerging questions" (p. 110). This recursive process (LeCompte & Schensul, 1999b) was used to determine journal questions. Each week, with a few exceptions, responses to journal questions were collected and read. The next week's questions were decided based on themes or issues that emerged from the current and previous week's entries.

Journal questions focused reflection through a structural method commonly used in service-learning. The following is an example of one week's journal questions:

1. What did you do this week in this course?
2. What did you learn this week?
3. How did you learn it?
4. What does it mean to *do* statistics?
5. What statistics, if any, did you *do* this week? Before this week?
6. What seems to be working well? What could be better? How so?
7. What challenges lie ahead?
8. What are your next steps?
9. Other thoughts/comments…

This method structures questions according to "what," "so what," and "now what" format (Borton, 1970). That is, reflection begins by asking what happened, then asking the meaning behind what happened, and finally by asking what action should happen next. Additional questions aimed to uncover attitudes and beliefs were also strategically inserted.

Procedures and Analysis

Timeline

Data analysis began in conjunction with data collection. Data collection began during the first week of February 2005 and concluded at the close of the course, the first week of May 2005. In interpretive research, analysis is a recursive process of meaning-making that should be carried out throughout the research. Plus, if analysis begins only after all data has been conducted, a researcher runs the risk of becoming overwhelmed by the magnitude of the data (Merriam, 1998). I conducted preliminary analysis throughout data collection, that is, all data were open coded, initial themes were recorded, and I began the process of refining codes. Once all data were gathered, themes were completely refined and structures formed.

During the first week of the course, participants were given the SMSA (Pre) to complete during class and the first narrative task to complete outside of class and return by the end of the first week. Upon receipt, both sets of data were open coded (Creswell, 1998) for initial emerging categories. Starting the second week of class, participants began writing responses to journal questions. These questions were emailed to participants at the beginning of the week and responses were due by Saturday of that week. This allowed me time to read and analyze journals before deciding on the next set of questions. In the second to the last week of the course, students completed the SMSA (Post) during class and were give the second narrative task to complete outside of class and return by the end of that week. Again, both sets of data were immediately open coded. Course grades were determined by the beginning of the last week of the course and all students were notified of their grade. Following this notification, consent and

assent forms were unsealed to determine study participants and data from the non-participant was discarded. A member checking session was then held with participants during a lunch period. Appendix K shows a timeline of research activities as they corresponded with course activities.

Description of Analysis

LeCompte and Schensul (1999a) describe three levels of data analysis: item analysis, pattern analysis, and structural analysis. Item analysis requires identifying the units of analysis that must be coded. Once items are initially coded, the pattern level of analysis begins. It involves organizing codes to see how they are related to each other and fit together. Through pattern analysis, structures are formed. Structural analysis involves assembling the patterns in larger groups based upon relationships. Through structural analysis, the phenomenon under study is explained. What follows is a description of the item, pattern, and structural analysis conducted in this study.

Item analysis and coding.

I developed my codebook (Appendix L) by following LeCompte and Schensul's (1999a) guidelines for coding open-ended survey data. First, I created variable names according to the research questions. For example, for the questions, "What are high school students' attitudes and beliefs regarding mathematics and statistics, respectively? In particular, what were students' general beliefs about the nature and utilization of mathematics and statistics, beliefs about what it means to *do* mathematics and statistics, and beliefs about confidence to do mathematics and statistics?" the variable names were Attitudes Toward Mathematics (ATM), Attitudes Toward Statistics (ATS), General

Beliefs About Mathematics (GBM), General Beliefs About Statistics (GBS), Beliefs About Doing Mathematics (BDM), and Beliefs About Doing Statistics (BDS).

Next, I entered SMSA (Pre) data into a spreadsheet and assigned variable names to each of the questions, 1 - 17. I assigned variable names to each part of the first narrative assignment as well. Subsequently, I used a combination of inductive and deductive analysis to create initial associated codes per variable name. Inductively, I conducted a content analysis of each item on the SMSA and the first part of the first narrative ("Please explain what it means to you to *do* mathematics") to create associated codes. Deductively, I utilized self-efficacy theory for codes pertaining to sources of self-beliefs in order to code relevant items from the second part of the first narrative assignment ("Describe how you believe your experiences, both inside and outside of school, have caused you to feel more or less confident in doing mathematics"). Self-efficacy theory had significant implications in the coding of these data; however, I remained open to the idea that there may be additional codes beyond this framework as well. As it turned out for the first narrative, the data did not support any codes beyond those indicated by self-efficacy theory. This was not the case for the second narrative.

Every week, relevant items from participants' journals were assigned a variable name and responses were entered into another spreadsheet. Similarly, I conducted a content analysis of journal data to create associated codes. As patterns began to emerge, I was able to formulate journal questions specifically aimed at gaining deeper insight and to confirm or disconfirm suspected patterns.

Once the SMSA (Post) and the second narrative were collected, they too were entered into a spreadsheet and items were assigned variable names. Initial associated

codes were assigned similarly, through inductive content analysis. Deductive coding according to self-efficacy theory did not work well with the second part of the second narrative ("Describe how you believe your experiences, both inside and outside of school, have caused you to feel more or less confident in doing statistics") because responses frequently referenced service-learning, a variable name I did not initially associate with self-efficacy theory. Therefore, inductive analysis was applied there.

Pattern analysis.

Upon gathering the last set of data, I began an extensive process of refining my codebook. This process is similar to what LeCompte and Schensul (1999a) describe as pattern analysis. I examined data from each of the three sources separately. I performed several iterations per source that involved organizing initial codes and supporting quotes, looking for patterns and themes and collapsing codes. I conducted a member-checking session with participants to verify my initial findings and clarify any uncertainties. Based on this session, I did not find a need to create or remove any codes from my refined list. Finally, I compiled supporting quotes for each refined code from each source in a single spreadsheet according to variable name. I performed a final iteration of similar code collapsing. Once I was satisfied that I could no longer reduce my codebook, I stopped. In the end, it consisted of nine variable names and a total of 70 codes.

Structural analysis.

LeCompte and Schensul (1999a) suggest creating a collection of quotations as one method of conducting structural analysis. Because of the way in which I conducted item and pattern analysis, I was able to apply this method easily. When I was done with pattern analysis, I was left with an initial structural model complete with supporting

quotations of varying depth depending on the data source (SMSA responses tended to be less detailed, journal responses moderately detailed, and narratives considerably detailed). Each variable name consisted of associated (refined) codes and each code consisted of associated themes represented by quotations and organized by participant and data source. Since each variable name corresponded to one or more research questions, my structural model provided an effective representation of the study's findings. The results of my study are reported in the next chapter accordingly.

CHAPTER 4

RESULTS

This chapter is organized under three primary headings: attitude and beliefs regarding mathematics, attitudes and beliefs regarding statistics, and the role of service-learning. Each of the three sections opens with its corresponding research question and a table that summarizes relevant themes. Illustrative quotations are provided to substantiate themes. Quotes are taken from the three data sources – SMSA (Pre and Post), journals, and narratives – as well as from member checking notes and my reflexive journal. All but one of the research questions is addressed in this chapter. Research question 2, "To what extent do attitudes and beliefs regarding mathematics parallel those regarding statistics?" is reserved for the conclusions and discussion section in the next chapter.

Attitudes and Beliefs Regarding Mathematics

> *What are high school students' attitudes and beliefs regarding mathematics? In particular, what are students' general beliefs about the nature and utilization of mathematics, beliefs about what it means to do mathematics, and beliefs about confidence to do mathematics?*

Primarily, the SMSA and the first narrative provided insights into students' attitudes and beliefs regarding mathematics. Below, I report on students' general beliefs about the nature and utilization of mathematics, beliefs about what it means to do mathematics, attitudes toward mathematics, and beliefs about confidence in doing mathematics. Students' mathematics-related responses to the SMSA (Pre) and the SMSA (Post) were relatively stable. Quotes were chosen to illustrate themes as well as to

demonstrate this stability. Table 3 summarizes the themes pertaining to mathematics-related attitudes and beliefs. A discussion of each category and its associated themes follows.

Table 3

Summary of Attitudes and Beliefs Regarding Mathematics

Category	Themes
General Beliefs About Mathematics	1) Mathematics is about manipulating numbers; 2) Mathematics is difficult; 3) Mathematics will be useful on the job, for managing money, and for daily activities.
Belief About Doing Mathematics	1) Currently, doing mathematics means working practice problems; 2) Currently, doing mathematics means using formulas and equations to get the correct answer; 3) In the future, doing mathematics will mean applying skills on the job or in daily life; 4) Mathematicians doing mathematics is a process of discovery and innovation; 5) Mathematicians do mathematics that is too difficult and complex for most people.
Attitudes Toward Mathematics	1) Students like mathematics that they perceive to be simple and easy to understand; 2) Students dislike mathematics that they perceive to have no future application.
Confidence Doing Mathematics	1) Students feel confident about doing mathematics with which they have had positive performance mastery experiences; 2) Students' confidence to do mathematics is influenced by social comparisons; 3) Teachers influence students' confidence doing mathematics; 4) Family influences students' confidence doing mathematics.

General Beliefs About Mathematics

Several themes surfaced through analysis with regard to students' general beliefs about the nature and utilization of mathematics. Students were asked to explain what mathematics is, what topics or skills it involves, and the ways, if any, that mathematics can be useful. Three general beliefs were common among a majority of students: 1) Mathematics is about manipulating numbers; 2) Mathematics is difficult; and 3) Mathematics will be useful on the job, for money management, and for day-to-day activities.

Mathematics is about manipulating numbers.

Overwhelmingly, students referenced "numbers" when describing mathematics. To illustrate, Carrie (SMSA Pre) wrote, "Mathematics is about numbers and putting numbers together in different ways, such as addition and multiplication. I think it takes someone who is good with numbers to be good with math." Adam (SMSA Pre) wrote, "Mathematics is about having numbers that fit into an equation." Brad (SMSA Post) wrote, "Mathematics is about working with numbers in order to get answers to questions." Dana (SMSA Post) wrote, "Mathematics is about defining things by numbers and letters which would be more complicated with words."

This numbers-based concept of mathematics may seem predictable; however, it played a role in students' initial reactions to service-learning that I had not anticipated. The beginning of the course required more reading and writing and very little number manipulation. In my reflexive journal entry, I noted:

> So far, I've given the students a lot of background reading material on refugees and The Agency. I talked to them in detail about the service-learning project and they seem enthusiastic about it. I imagine they are not used to doing so much reading in a math class and I wonder how they will adjust. (February 8, Week 2)

Indeed, this numbers-based belief about mathematics carried over as we began our study of statistics using the service-learning model, a model that was new and unfamiliar to students. Dana (Journal, Week 3) wrote, "I'm frustrated. I'm forgetting stuff we learned last year. I know we're gonna get to math, but it's been weeks now." I discuss this issue in greater detail in the next sections, but its significance is such that it is important to mention early on.

Mathematics is difficult.

Students also believed mathematics to be a subject that is difficult to comprehend. Kelly (SMSA Pre) wrote, "Mathematics is difficult for me because I can't do computation without a calculator." Eric (SMSA Pre) wrote, "Mathematics is hard and not very interesting because it is seems like there is little point to what we do in math." Carrie (SMSA Post) wrote, "Mathematics is not all that interesting and can be difficult when I do not understand a topic that well because it is not a subject that interests me very much." Paula wrote:

> Mathematics is sometimes illogical and hard for me to comprehend because I'm a rational and logical thinker and math to me isn't straightforward. When I envision myself doing mathematics, I see myself trying very hard, being confused, and getting it all wrong. (SMSA Pre)

Interestingly, despite the view that mathematics is "hard" and "illogical," students readily offered examples of how mathematics will be useful to them in the future.

Mathematics is useful.

The three most frequently referenced uses of mathematics were for job purposes, personal finances, and for common, everyday uses or "cash register math," as Dana (SMSA Pre) puts it. She explains, "Mathematics may be useful later for buying cars, paying taxes, simple cash register math, getting loans, and in art, math is useful a lot." In addition to personal finances and everyday uses, some students were specific with regard to types of jobs through which they will utilize mathematics in the future. For example, Brad (SMSA Pre) wrote, "Mathematics may be useful later for investing money, paying taxes, building things, or graphic design." Kelly (SMSA Post) wrote, "Mathematics may be useful later for teaching first graders and balancing checkbooks." Others were more general. Sam (SMSA Post) wrote, "Mathematics may be later useful for a profession". Adam (SMSA Post) wrote, "Mathematics may be useful later for everything in life. It's good from counting money to science. It's always going to be helpful, I think."

Beliefs about Doing Mathematics

In the first narrative, students were asked to explain what it means to *do* mathematics. In the SMSA, they were asked to describe what they envision when they picture themselves doing mathematics. They were also asked to describe what they envision when they picture mathematicians doing mathematics. There were five themes that surfaced. The first three pertain to students and the last two pertain to mathematicians. They are as follow: 1) Currently, doing mathematics means working practice problems; 2) Currently, doing mathematics means using formulas and equations to get the correct answer; 3) In the future, doing mathematics will mean applying skills on the job or in daily life; 4) Mathematicians doing mathematics is a process of discovery

and innovation; 5) Mathematicians do mathematics that is too difficult and complex for most people.

Doing mathematics now.

For students, doing mathematics is currently a school-based activity that involves practicing problems that involve formulas and equations in order to find correct answers. Carrie (Narrative 1) wrote, "What I do in math is take notes and do lots of problems. I do the homework and ask teachers and friends for help." Kelly (Narrative 1) wrote, "To me, doing mathematics is mainly doing math homework." Dana (SMSA Post) wrote, "When I envision myself doing mathematics, I see myself doing SAT practice problems." Mary (Narrative 1) wrote, "To do mathematics means to know how to solve problems using equation or formulas." Paula wrote, "To me, to do math is to be able to understand the concepts and strategies well enough to complete the assignments."

Doing mathematics in the future.

Students described doing mathematics in the future in the same ways that they described the uses of mathematics, that is, in terms of jobs, personal finances, and everyday uses. Brad (SMSA Pre) wrote, "When I envision myself doing mathematics, I see myself either managing a business or doing design of some sort." Mary (SMSA Post) wrote, "When I envision myself doing mathematics, I see myself doing problems at work that involve some basic skills from math." Paula (SMSA Post) wrote, "When I envision myself doing mathematics, I see myself doing nothing other than planning my budget."

Mathematicians doing mathematics.

There was a discrepancy between students' beliefs about what it means for *them* to do mathematics and what it means for *mathematicians* to do mathematics. Students

described the work of mathematicians as being highly sophisticated. Carrie (SMSA Pre) wrote, "When I envision mathematicians doing mathematics, I see them learning new things and forming new math theories." Angie (SMSA Post) wrote, "When I envision mathematicians doing mathematics, I see them doing lots of high tech math, very advanced, and maybe about to prove a theory. Dana (SMSA Pre) wrote, "What I envision mathematicians doing mathematics, I see them thinking about symmetry of doughnut-shaped things and figuring out undiscovered patterns."

Students spoke highly of the work of mathematicians and described a mathematician's version of "doing mathematics" as an unattainable task. Eric (SMSA Pre) wrote, "When I envision mathematicians doing mathematics, I see them writing what I can't understand." Paula (SMSA Post) wrote, "When I envision mathematicians doing mathematics, I see them working diligently but not having any trouble like me. I see them working faster." In other words, what mathematicians do is different from what students do. Further, while students view themselves doing and using mathematics in the future on the job and in daily life, students do not view themselves in the future doing the mathematics of a mathematician.

Attitudes Toward Mathematics

Students were asked to identify aspects or topics pertaining to mathematics that they like, if any, as well as those that they dislike. Two primary themes emerged: 1) Students like mathematics that they perceive to be simple and easy to understand; 2) Students dislike mathematics that they perceive to have no future application. Conversely, students dislike mathematics that they perceive to be work intensive and difficult, and like mathematics that they perceive to have direct applications to their lives.

Evangelopoulos, Sidorova, and Riolli (2003) concluded that perceived ease of the course has a direct positive influence on attitudes toward the course. In this study, perceived ease of mathematics concepts had a direct positive influence on attitudes towards mathematics concepts. Eric (SMSA Pre) wrote, "I like mathematics that involves very easy algebra because I understand it." Paula (SMSA Pre) wrote, "I like mathematics that involves computation with positive integers because it's clean cut and usually has a simple procedure." Kelly (SMSA Post) wrote, "I like mathematics that involves reading graphs that tell about a population because it's easier than algebra." The time commitment of mathematics influenced Brad's attitude. He wrote, "I dislike mathematics that involves graphing things because it takes a long time" (SMSA Pre) and " I dislike mathematics that involves graphing and trigonometry because they are boring, hard, and time consuming" (SMSA Post).

Students like to be able to use the mathematics they are learning or at least foresee of some future use. Mary wrote, "I dislike mathematics that involves memorization of ways to solve different things because it seems pointless to learn" (SMSA Pre) and "I like mathematics that involves using formulas that make sense and applying it to real life because it makes it seem important" (SMSA Post). Angie wrote:

> I like mathematics that involves things I would use later in life whether in the work force or in every day. I dislike mathematics that involves stuff that I'll never use or really need to know because I'm forced to learn it to pass a test or class. (SMSA Pre)

It is not unreasonable that students seek out meaning and application in mathematics. Students acknowledge the usefulness of mathematics and can envision themselves using mathematics in the future, yet their school-based experiences with mathematics have not

given them opportunities to practice using mathematics in these practical ways. Paula views mathematics as irrational:

> I've never done so well in math before, simply because it didn't make sense in my mind. I'm a rational thinker and math just always seemed to be the opposite of that. I needed to be able to implement it in some way with a hands-on approach. (Narrative 2)

It follows that students reference different types of experiences doing mathematics as influencing their confidence to do mathematics.

Confidence to do Mathematics

Through the SMSA and narratives, students were asked to describe their confidence to do mathematics including experiences both in and out of school that influenced confidence. Four themes emerged: 1) Students feel confident about doing mathematics with which they have had positive performance mastery experiences; 2) Students' confidence to do mathematics is influenced by social comparisons; 3) Teachers influence students' confidence doing mathematics; 4) Family influences students' confidence doing mathematics.

Recall that self-efficacy theory identifies four primary sources of self-efficacy beliefs – performance mastery experiences, vicarious experiences, verbal and social persuasion, and physiological states – as well as four primary sources of academic self-efficacy – family and peer influences, schooling (including teachers), and transitions in schooling. The four themes that emerged in this study – performance mastery experiences, social comparisons, and teacher and family influences - do not exhaust the sources of self-efficacy as indicated by the literature, but they are consistent with it.

Performance mastery experiences.

Performance mastery experiences referenced by students varied from classroom-based experiences to real life experiences. Lisa remembers an experience from elementary school that positively influenced her confidence to do mathematics:

> When I was in the 5th grade, we used to have to do times tables. They were part of our goals. There were 100 problems for as fast as you could with no calculator. They were always the first goals that I would finish. Also, the math on my SAT is the highest out of the other sections. (Narrative 1)

While Lisa reported confidence to quickly and accurately multiply numbers and to do SAT problems, when pushed to delve deeper into the meaning behind her work, Lisa's confidence began to wane. Lisa wrote, "I don't like learning new terms. I would just like to work with numbers. I know it's good to understand the meaning of what I'm doing but for me, just remembering how it is done is good enough" (Journal, Week 6).

While Lisa's positive experiences doing computation built her confidence, Kelly's negative experiences had an adverse effect on her confidence. Kelly explains:

> Another reason I have low confidence in math is my lacking ability to do computation. I remember in elementary school learning how to add and subtract using my fingers or lines on a piece of paper (now I can use a calculator). In late elementary I would sit where I could see a times table and got permission to use multiplication tables on tests. I believe that if I instantaneously knew these facts like other people I would be more confident in math. (Narrative 1)

Kelly also alluded to transitions in schooling and social comparisons as influencing her confidence:

> I did not get a lot of math at my middle school, so when I came to my new school, I took seventh grade math in the eighth grade and in ninth grade walked down to the junior high to take math. I felt the classes were a good level for me. I do not know if this has lowered my confidence, but it has not raised it. I guess failing a higher-level math class would have lowered my confidence even more. Needing aids that other students do not need added to my lack of confidence. (Narrative 1)

Paula's confidence to do mathematics was extremely low. Like Kelly, her confidence was also negatively influenced by social comparisons:

> My real big issue came in the eighth grade when I started taking Algebra I. I just could never seem to understand the objectives and became the poorest student in the class, which was new for me. Math has always seemed to frustrate me because I always seem to do fairly well in all other areas, but in this one I seem to be below everyone else. When I step into a math class I suddenly feel as though I've lost some of my intelligence. I don't feel as smart. This ruins my spirit and sometimes, I believe, causes me to psych myself out and further my lack of understanding. In math, I always feel dumb. (Narrative 1)

While Paula's confidence doing school-based mathematics is low, she goes on to explain a real life experience in which she is successful in using mathematics:

> I do not really feel that I get a well enough understanding of the material to put it to use. Except, I've always been able to compute tax and bills. I never seem to do the computation wrong. I guess it's because it's relevant and that type of numbers seem real to me. (Narrative 1)

Paula was quoted earlier saying that she needs to be able to implement what she is learning through a hands-on approach. Apparently, she knows herself well. A service-learning-based course would seem ideal for this type of student. Indeed, Paula's transformation through the course was remarkable.

Other students referenced negative real world experiences. Angie has low confidence doing mental mathematics and working with money:

> I'm not very confident in math. Like when factoring a tip and stuff like that I still have a hard time. I also can't do math in my head very easily so I make the person I'm with help me. Figuring change is also slightly hard to do and for the longest time, I avoided giving change when I paid for something. (Narrative 1)

Mary also describes experiences dealing with money during two summer jobs:

> I worked in a candy store two summers ago and we had to add up the candy that people chose and subtract it from how much money they gave us and add tax and everything like that. I hadn't thought my summer would ever have anything to do with math but it did. I found myself not using the calculator and being able to add

> and subtract the differently priced candy and come up with tax. It was a very limited amount of math but I could feel myself getting stronger and holding on to what I'd learned during school.
>
> For my job this summer I worked on the lobster docks in Maine and used a calculator as well. My math skills were lacking this summer and even adding up the bushels of bait and subtracting it from their pay was extremely difficult. I kept getting slips wrong and having silly complications with multiplication. I felt like I had gone back a decade in my skills. This made me a lot less confident in just the basic mathematics. (Narrative 1)

Mary's first summer job used a "limited amount of math", in a real world context. It was a positive, confidence-building experience for her. However, Mary lost her confidence doing "basic mathematics" when her second summer job required mathematical tasks that she was unable to successfully complete.

Social comparisons.

Two examples in which social comparisons have negatively influenced confidence to do mathematics have been mentioned already. Others shared similar experiences. Sam wrote:

> I don't think that I have ever been confident using math in groups. From very early on I remember being uncomfortable using math around other people. I have no problem with math on my own or with someone I am very comfortable with but in front of others I always feel awkward using math. I'm not sure what has caused this feeling, but I have always taken more notice of the problems that I got incorrect in front of others than the problems that I got correct. Inside of the classroom math has always felt like a bit of a competition over who can demonstrate their understanding of it and perhaps their overall intelligence. (Narrative 1)

Adam's confidence doing mathematics was also negatively influenced by social comparisons:

> I know that one factor in losing my confidence in math is the comparison of the math classes I have been in to the ones that some of my peers have taken. When you are taking a class in your senior year and other students had that class in their sophomore year you are going to feel less confident about your skills in mathematics. An outside experience would be taking the SAT's. I did not score as

> high on the math section as some of my peers who thought it was not that hard. (Narrative 1)

As described earlier, the course in which these students were enrolled was a slower-paced course that allows extra time to cater to students' specific needs. Not every student experienced negative social comparisons as a result of taking the slower-paced route. For example, Lisa (Narrative 1) wrote, "There would be times when I didn't understand the material or when to use what. But working through the steps at my own pace in order to fully understand helps me gain more confidence." With the support of her parents, Carrie did not experience negative social comparisons:

> At the beginning of sophomore year I decided to take Geometry and Trigonometry instead of Functions, Statistics, Trigonometry and Geometry, even though I had not done badly in Algebra freshman year. My parents and I thought that it would be a better path for me because it would give me more time to absorb and understand the information. No one has ever made me feel stupid in school. I have never felt like anyone is like, "Oh you're in stupid math." (Narrative 1)

Teacher and family influences.

Teachers can play a role in creating an atmosphere that positively or negatively influences students' confidence. Dana describes the positive influence of a previous teacher:

> My math teacher last year made me feel confident. He always made me feel smart when I came up with an answer or figured something out before he explained it. He made us feel like we weren't in slow math class, but that we were all learning important things and could be good at it. He really helped me build my confidence in math. (Narrative 1)

Kelly's memories go back to elementary school. Even though she realizes now that she was not the target, per say, of her teacher's negative comments, they have remained with her even many years later:

> I have unpleasant memories of elementary teachers announcing to the class that students were not smart if they had to use their fingers to add and high school teachers who lecture the class that using a calculator hurts your brain keeping you from thinking. Even though these comments were not specifically toward me, I felt as if I was being ridiculed. (Narrative 1)

Angie shared a similar negative experience:

> One teacher was particularly hard because he would make huge generalizations about that everyone could do the basic math skills, and if you couldn't there was something wrong with you. That didn't bother me too much, though, because I'm used to teachers saying that. (Narrative 1)

Angie downplays this negative experience as something that she just expects to happen. Recall that Angie reported that she used to avoid using coins when paying for items because of her difficulty with computation. These are defenses she has developed to compensate for her low confidence in doing mathematics.

Like teachers, family can also either positively or negatively influence students' confidence to do mathematics. Carrie felt supported by her family:

> The main factors that have influenced my confidence to do mathematics are mainly school and my parents. My parents have always helped me with math if I needed help. If I ever do not understand a math assignment that I am doing for homework my dad or brother, who are both good at math, will always help me. They never make me feel stupid for not understanding something. (Narrative 1)

While Kelly's experiences with teachers has not all been positive, her mother's support has sustained her:

> I think almost all my confidence in my ability to do math is from my mother's support. She was a math teacher earlier in her life and loves math. She has always helped me with my homework and helped me study for tests. She tells me I am good at math. She is understanding and sympathetic with my difficulties with math. She has been supportive of me needing accommodations and helped me get them. (Narrative 1)

Dana had the reverse experience. Recall that Dana described her experience with her previous math teacher as one in which she was made to feel smart and good at math and

therefore, positively influenced her confidence. On the other hand, Dana describes her experiences at home as negatively influencing her confidence. She explains:

> My confidence in math in general started off pretty low. My mom always told me that math was boring and difficult. I was turned off from math from the get go. My confidence in math has a lot to do with my sister. Because she is so good at math, I have always assumed I wasn't and left it alone. (Narrative 1)

To conclude, students' confidence to do mathematics can be positively or negatively influenced by performance mastery experiences. These experiences can be classroom-based or occur in real life. Students' confidence to do mathematics is also influenced by social comparisons, though placement in a slower-paced course does not necessarily mean confidence is negatively influenced. Finally, students' confidence doing mathematics can be positively or negatively influenced by encouragement or discouragement, respectively, from teachers and family.

Attitudes and Beliefs Regarding Statistics

> *What are high school students' attitudes and beliefs regarding statistics? In particular, what are students' general beliefs about the nature and utilization of statistics, beliefs about what it means to do statistics, and beliefs about confidence to do statistics?*

The SMSA, journals, and narratives provided insights into students' attitudes and beliefs regarding statistics. Similar to the previous section, I report students' general beliefs regarding statistics, beliefs about what it means to *do* statistics, attitudes toward statistics, and beliefs about confidence to do statistics. Students' responses to the SMSA (Pre) and the SMSA (Post) varied not in meaning, but in depth. This was to be expected because students did not have the experience with statistics like they had with other kinds of mathematics. Therefore, they tended to be less able to articulate attitudes and beliefs about statistics at the beginning of the course than the end. Again, quotes are provided

from the pre-survey and the post-survey that illustrate this phenomenon. Table 4 summarizes themes pertaining to students' attitudes and beliefs regarding statistics.

Table 4

Summary of Attitudes and Belief Regarding Statistics

Category	Themes
General Beliefs About Statistics	1) Statistics is about finding meaning in data; 2) The math that is needed in statistics includes basic arithmetic and creating and reading graphs; 3) Statistics will be useful for doing research projects and for making decisions.
Beliefs About Doing Statistics	1) Doing statistics means collecting, analyzing, and interpreting data on a sample of people; 2) Statisticians doing statistics means collecting, analyzing, and interpreting data on a large scale; 3) Doing statistics does not include writing evaluation plans.
Attitudes Toward Statistics	1) Students like statistics that involves real life scenarios and people; 2) Students dislike statistics that involves difficult or complex mathematics.
Confidence Doing Statistics	1) Students are confident about doing statistics that they like, and conversely, students are not confident about doing statistics they do not like; 2) Students are more confident about doing statistics than mathematics.

General Beliefs About Statistics

Students were asked to describe general beliefs about the nature and utilization of statistics in the same way that they were asked to describe these beliefs regarding mathematics, with one exception. They were asked to explain what statistics is, what topics or skills it involves, and the ways, if any, that statistics can be useful. Students were also asked to describe the math that is needed in statistics. The SMSA Pre asked students to describe these beliefs from an anticipatory stance, since they had not been exposed to statistics in a classroom setting before, whereas the SMSA Post asked students to describe current beliefs having completed the course. Three primary themes emerged: 1) Statistics is about finding meaning in data; 2) The math that is needed in statistics includes basic arithmetic and creating and reading graphs; 3) Statistics will be useful for doing research projects and for making decisions.

Finding meaning in data.

Students believed statistics to be about finding meaning behind numerical data instead of about manipulating numbers to finding answers to practice problems. As to be expected from a sample of students having no previous courses in statistics, students' final descriptions tended to be more sophisticated than initial descriptions. For example, Dana wrote, "Statistics is about analyzing math and seeing what it means" (SMSA Pre) and "Statistics is about asking the right questions, finding a good and representative subject matter, and using math to analyze results of research" (SMSA Post). Paula wrote, "Statistics is about counting, computation, lists, order, and comparing data" (SMSA Pre) and "Statistics is about observing and testing in order to find trends or probabilities" (SMSA Post). Eric had a limited concept of statistics at first: "Statistics is about numbers.

I don't really know" (SMSA Pre), but by the end of the course, a more solid concept: "Statistics is about analyzing data into an explanatory way" (SMSA Pre). Lisa wrote, "Statistics is about knowing how to understand numbers" (SMSA Pre) and "Statistics is about interpreting data to find what the information is saying and being able to use charts and graphs" (SMSA Post).

Mathematics needed for statistics.

Students were asked to identify which mathematical concepts would be needed in order to do statistics. Students believed doing statistics requires simple arithmetic and graphing skills. This may be attributed to the fact that because the course was at the introductory level, the extent of mathematics required was minimal. Carrie (SMSA Pre) wrote, "The math that will be needed in statistics includes multiplication, addition, subtraction, division, and percents." Paula (SMSA Pre) wrote, "The math that will be needed in statistics includes counting, computation, ordering, and chart-making" (SMSA Pre). Dana (SMSA Post) wrote, "The math that is needed in statistics includes not many skills, just memorizing a few simple rules." Kelly (SMSA Post) wrote, "The math that will be in statistics includes solving some equations and interpreting graphs."

While the course was not mathematically complex, it did require more than just finding answers to problems. Because of the nature of statistics, students were posed the more challenging task of actually making meaning of data through analysis and interpretation. Recall Lisa, who was content being the fastest to complete multiplication tables, but was resistant to the push to understanding the meaning behind her work. "Just remembering how it is done" was "good enough" for her. Also recall Paula, who thought that mathematics was "illogical" and "hard," and who always feels "dumb" in math.

Paula wrote, "Statistics is easier than other math because it's straight forward. I feel as though it is more useful and easier to understand" (SMSA Pre). At the end of the course, Paula maintains these beliefs: "Statistics is easier for me than math because it seems more real. When I envision myself doing statistics, I see myself being more successful than doing normal math" (SMSA Post). While Lisa felt proficient in her mathematical abilities, she had difficulty situating her work in real scenarios to make interpretations. Whereas Paula's confidence in her ability to do *classroom-based* mathematics was very low (she felt confident using math in the context of money *outside of class*), she found it easy to do statistics because she believed there was meaning to her work. Carrie felt similarly: "Statistics is not too difficult and more interesting because you are able to learn things about groups while working with numbers" (SMSA Post).

Uses of statistics.

Another interesting theme emerged with regard to the usefulness of statistics. Students believed they would use statistics in the future in the same ways that they were doing statistics in the course – to create surveys, carry out research projects, and write reports. Kelly (SMSA Pre) wrote, "Statistics may be later useful for surveys of how many people do something." Carrie (SMSA Pre) wrote, "Statistics may be useful for reports that I may do on certain groups." Sam (Journal, Week 7) wrote, "I will be more capable of creating surveys in the future." Lisa (SMSA Post) wrote, "Statistics may be later useful for putting the results of a survey together so it is easy to read."

Students also frequently referenced uses of statistics that involved real life decision-making of some type, whether financial, job-related, or social. Adam wrote, "Statistics may be later useful for deciding if you want to buy a product or not" (SMSA

Pre) and "Statistics may be later useful for determining to invest in something or not" (SMSA Post). Paula (SMSA Pre) wrote, "Statistics may be later useful for my career later in life in management and marketing." Similarly, Brad (SMSA Post) wrote, "Statistics may be later useful for investing, marketing plans, etc.." Mary's descriptions were more socially based. She wrote, "Statistics is needed and well used in our society because it helps progressive thinking" (SMSA Pre) and "Statistics may be later useful for proving different theories in order to improve our technology and development – to solve problems in the world" (SMSA Post).

Beliefs About Doing Statistics

Through the SMSA, journals and the second narrative, students were asked to explain what it means to *do* statistics. Again, students were asked to describe what they envision when they see *themselves* doing statistics and when they see *statisticians* doing statistics. Interestingly, students made no distinction between what it means to do statistics now and what it will mean to do statistics later in life. Also, at least in substance, students believed that students doing statistics is equivalent to statisticians doing statistics. Essentially, these three themes emerged: 1) Doing statistics means collecting, analyzing, and interpreting data on a sample of people; 2) Statisticians doing statistics means collecting, analyzing, and interpreting data on a large scale; 3) Doing statistics does not include writing evaluation plans.

Students doing statistics.

Again, students' descriptions of what it means to do statistics tended to become more sophisticated by the end of the course. Mary wrote, "When I envision myself doing statistics, I see myself calculating lists of numbers and trying to prove things or collect

data" (SMSA Pre) and "When I envision myself doing statistics, I see myself interpreting graphs and recording information" (SMSA Post). Adam wrote, "When I envision myself doing statistics, I see myself using percentages and fractions" (SMSA Pre) and "When I envision myself doing statistics, I see myself making graphs from categories and trying to find a pattern from options" (SMSA Post). Adam elaborates:

> What it means for me to do statistics is to apply concepts to a group of peoples' responses in order to analyze them. There are many different factors that come into play when a large group is making a decision or choice. Measuring a group's response is what doing statistics is to me. When analyzing, some of the things you look at in order to deduct a statistic are the majority, minority, the spacing between choices, and the average of the responses. (Narrative 2)

Angie wrote, "When I envision myself doing statistics, I see myself collecting data" (SMSA Pre) and "When I envision myself doing statistics, I see myself evaluating data using a calculator, graphing, making an analysis of the data" (SMSA Post). Like Adam, when asked to elaborate in her narrative, Angie describes the role of people in the process of doing statistics:

> In statistics, you make questions to ask a group of people, and collect information. You have different errors that can occur with your sample, problems with your questions, and the people that you ask being biased in some way. It deals with probability and graphs to show what you've found. (Narrative 2)

In the member-checking session at the end of the course, students confirmed this theme:

> Leong: I've asked you what it means to do statistics. Based on your responses, doing statistics means to collect, analyze, and interpret numbers. Does this sum it up?
> Carrie: Yes, and figuring out something about a group of people.
> Group: Concur
> Leong: So, doing statistics involves working with people?
> Group: Concur
> Mary: That's what I like about statistics versus other kinds of math.
> Paula: Yes. I need to be able to apply what I'm learning in order to be interested in it. I like learning hands-on. (Member Check, May 4th)

Whereas students believe mathematics to be centered on numbers, they believe statistics to be centered on people. Further, this people-centered belief renders statistics more likable and interesting. At the beginning of the course students were doing background research on refugees, some of which was online. Mary wrote:

> By being interested in what I was reading about in the websites and not just droning out and doing unmeaningful math problems over and over, I've learned that I could enjoy math when it's related to something that I care about on a more personal level. (Journal, Week 2)

Another online assignment required students to choose an opinion poll, analyze it for believability, and share results with the class. Kelly (Narrative 2) wrote, "When we looked up surveys online, I found that interesting because we saw how the math we were doing directly related to meaningful topics about Americans' views."

Statisticians doing statistics.

Students described what statisticians do in similar ways. The only difference, in some cases, between what statisticians do and what students do is with regard to magnitude and sophistication. In substance, there was no difference. Paula wrote, "When I envision statisticians doing statistics I see them predicting trends in the stock market" (SMSA Pre) and "When I envision myself doing statistics, I see myself making a few mistakes, but basically doing the same as statistician, but on a smaller scale" (SMSA Pre). Mary writes, "When I envision statisticians doing statistics I see them writing up reports for the world using surveys" (SMSA Post) and "When I envision myself doing statistics, I see myself interpreting graphs and recording information" (SMSA Post). Adam wrote, "When I envision statisticians doing statistics I see them taking large polls about an idea or product and giving it to the public or a private company" (SMSA Post)

"When I envision myself doing statistics, I see myself making graphs from categories and trying to find a pattern when choosing an option" (SMSA Pre). In other words, what statisticians do is virtually the same as what students do. This is a striking difference from the students' beliefs about mathematicians in relation to themselves.

Doing statistics versus writing evaluation plans.

By the end of the course students' concepts of doing statistics was well developed; however, there was a point at which I found it necessary to make some clarifications. This issue was mentioned earlier when describing students' general beliefs about mathematics, namely, the one that mathematics is about manipulating numbers. Recall Dana, who was feeling frustrated because she was not doing mathematics. Just prior to the submission of her journal entry describing this frustration, Dana discussed her concern with me:

> Today I was approached in a nice way by a student who expressed frustration in feeling that she was not learning any math. She said that she was very glad they were helping people, but that she was ready to do math. I listened to her carefully and then I responded by explaining that the evaluation plans they had been writing, while probably different from any math she had done before, were necessary to set us up to do some data analysis later. I explained that we were going to be shifting our focus toward working from the textbook and doing problems over the next couple of weeks. I asked her to give it a try and to check in with me again next week. (Reflexive Journal, February 22, Week 4)

Upon reading other students' journal entries for that week, I found that Lisa shared the same sentiment. She wrote, "I think our evaluation is going well. I would like to do some math" (Journal, Week 3).

To give some context, by end of the third week of class, students had completed background research pertaining to the service-learning project. They had been visited by representatives from The Agency, and seen the movie *Hotel Rwanda*. They had covered

topics including sampling, bias, variability, confidence statements, and margin of error, though a significant amount of class time had been allotted toward developing the evaluation plan for the service-learning project. The evaluation plan was much like a research proposal. Adapted from Reeves (n.d. a), it contained 12 sections including the introduction, background, purposes, limitations, audiences, decisions, questions, methods, sample, instrumentation, logistics, and timeline.

During the fourth week students finalized evaluation plans and we began covering other topics including sampling errors and survey design. Students spent more time working from the textbook than on evaluation plans. This was also the week that they completed the opinion poll believability analysis.

I felt compelled to address the class promptly in order to make clear the purpose of the project activities:

> (Some students) are having difficulty making the connection between project activities and statistics. This is interesting. What I'm seeing as an exciting opportunity for students to learn how to plan and conduct a real statistical evaluation, some see as having nothing to do with math. Up until now, I haven't explicitly pointed out connections between what real world researchers and statisticians do and what we're doing because I first wanted to see students' reactions to this new model. However, ethically, I do feel that it is time to address the class and help all of my students make these connections.
> (Reflexive Journal, February 25, Week 4)

I included a set of questions in the fourth week journal (due at the beginning of the fifth week) asking students first to explain again what it means to do statistics and then to describe what statistics, if any, they had done that week and also in previous weeks. Once journals had been submitted, but before I read them, I spoke to the class on the following Monday:

> Today I addressed the class about the concern that some were having that we were not doing any statistics. I did this by explaining that statisticians and researchers sometimes conduct project or program evaluations and may work for or be hired as an independent contractor by an organization needing these services. I reemphasized that this was the role they were taking on for The Agency. I explained the importance of developing a strong evaluation plan in advance and I pointed out the parts of the plan that directly tied into out reading from the textbook, i.e. writing research questions, selecting a sample, designing instruments. I further explained that while we have not yet gotten into the data analysis portion of the project, the process of designing a study is just as important in statistics, if not more so, than carrying out the study. They appeared to understand and seemed satisfied with this explanation.
> (Reflexive Journal, February 28, Week 5)

Then, I read the journal entries. To Dana, at this point in the course, doing statistics meant:

> …to make good questions and find a good group of people and use random numbers and figure out how to make a fare summary of one opinion or aspect of a group of people or things. This week, I analyzed other statistics and saw flaws in them. I must do statistics in my brain, very inaccurately all the time. I can sum up a group of people in my head. I can see people and take the information that they're all wearing name-brand clothing and assume that they're wealthy. That's kind of like statistics. (Journal, Week 4)

Dana's example regarding her assumption that people who wear brand name clothing have money is clearly an erroneous way to describe statistics. This echoes another inaccurate description, "When I envision myself doing statistics, I see myself writing down numbers on lined paper" (Dana, SMSA Pre). These findings further validated the need for the discussion I had with the class. By the end of the course, Dana's description of doing statistics had become more mature, "When I envision myself doing statistics, I see myself writing reports and charting information" (SMSA Post).

With the shift toward reading and working problems from the textbook, Lisa seemed to become more convinced that she was now actually doing statistics:

> In order to do statistics you have to have lots of samples. You also have to be aware that the information collected from sampling is not always accurate. This week, we had to read about statistics and looked at samples. (Journal, Week 4)

Carrie also believed that during the fourth week she had started doing statistics, but not much before then:

> Doing statistics means to learn ways of working with percents and surveys/polls. It also means learning things about groups of people. This week we mainly worked with statistics out of the statistics book that we are using. I wrote down the bolded words and learned them. And I also did the problems in the book that were assigned, which used many of the bolded words. Before this week we had not done as much dealing with statistics. I had read some articles dealing with statistics and learned some about statistics from The Agency. (Journal, Week 4)

Kelly shared a similar view:

> When one does statistics one finds out how a sample can represent a population's view on a subject without actually asking every member of the population. I am not sure if I did any this week. I guess interpreting charts is a kind of statistics and I did that this week. I have done surveys before this week in my Environmental Science class. (Journal, Week 4)

What became clear was that students only began to believe that they were doing statistics once they began working statistics problems from the statistics book. Adam wrote:

> To do statistics you have to look at every possible angle and outcome and then analyze them. The statistics we did this week and part of last week was learn the definitions in chapters two through four and then apply them to sample questions. (Journal, Week 4)

I had not anticipated this response from students. I realized that I had made an assumption that students would make the connection between doing statistics and *planning* an evaluation. Students' previous experiences with mathematics led them to believe that doing mathematics means working pre-made numerical problems from a textbook, like making cookies from the tube. What I was asking them to do was certainly more real, but it was also starting from scratch, trying to follow a new recipe, but missing

a key ingredient - numbers. While I did not suppose that writing the evaluation plan would be an easy task, I did not anticipate the extent that they would struggle:

> It's taking the students much longer than I anticipated for them to write the evaluation plan. I've been through several rounds of feedback with them and they still struggle. I think they are missing the significance of a solid plan and want to jump into number crunching. They seem resistant to reading and writing. (Reflexive Journal, February 16, Week 3)

I did expect, however, that once students began collecting items and could have some tangible object to quantify, they would begin to feel more "at home" with the statistics of the project.

Indeed, after students had collected a multitude of household items and my classroom was bursting at the seams, I gave them the task of deciding how they would evaluate each of the three programs. I describe what happened on this day in my reflexive journal:

> Today we had a breakthrough, though I admit I was worried at first. My room is packed full of items for The Agency so the students' task now was to decide how they would measure the success of each program. Initially, they were stumped and overwhelmed.
>
> After they grappled with this issue for a while, I began to pose some questions. I asked them to list some ways to measure things in general. They started with ideas like weight and volume. I asked them whether these units of measurement made sense for their project. They agreed they did not. Then one student suggested counting. Another student quickly countered, "But collecting 100 pencils isn't better than collecting 1 television, assuming the television works." A different student responded, "It is if you already have a television but nothing to write with."
>
> From there we led into a discussion about assessing value of items based on need and measuring in terms of quantity as well as quality. The Agency had provided us with a wish list containing items in greatest need by the refugees they serve. Since students collected items specifically from this list, they decided that all items were of equal need. They decided to devise a ranking system based on the quality of the item as well as to count the number of items donated. A five on the ranking scale would represent an item that was brand new; a zero would be assigned to an item that was not useable. (Reflexive Journal, March 28, Week 9)

Students were back in familiar territory and were energized by the prospect of finally getting to analyze the data they had collected. The rest of this week, students sorted, ranked, and logged items in spreadsheets. The next week was spring break. Upon their return, students continued with data analysis and began writing up the final reports. We also started our (brief) study of probability. The project did not easily incorporate probability, and rather than try to work it in unnaturally, I admitted to students that this was one topic that was an important part of the curriculum but that did not directly tie into the project.

We used a different textbook for the probability portion of the course, the textbook students had used for Algebra 2 (see Schultz, Ellis, Jr., Hollowell, and Kennedy, 2001). Probability can be a difficult concept to grasp at first, so it is helpful to begin with examples having easy-to-count and easy-to-visualize outcomes. Accordingly, most of the probability examples and problems dealt with inanimate objects like dice and marbles, instead of real life examples involving real people. Probability turned out to be a topic that many students did not like. Perhaps the findings relating to students' attitudes toward statistics explain why.

Attitudes Toward Statistics

Students' attitudes toward statistics were recorded through the SMSA, journals, and narratives. Students described likes and dislikes pertaining to statistics. Two primary themes emerged: 1) Students like statistics that involves real life scenarios and people; 2) Students dislike statistics that involves difficult or complex mathematics.

In the same way that students disliked mathematics that they perceived to have no direct application, students liked statistics involving real life scenarios, particularly those

involving people. Kelly (SMSA Post) wrote, "I like statistics that involves showing a populations' views on a topic because it has obvious real life applications." Kelly explains why she was fond of the textbook chosen for the course:

> The textbook we used was beneficial because almost all of the problems seemed real. I liked reading problems that could actually occur. It is interesting to want to find the result to the statistical problems if the numbers relate to a real population. I like the idea of being able to learn more about a population's views. (Narrative 2)

Angie likes statistics that "involves people and sampling, graphing, mean and median" because she "understands the meaning" of those topics (SMSA Post). Carrie likes statistics that "involves learning about groups" because she finds it "interesting" (SMSA Post). Brad likes statistics that "involves real life situations that are applicable because it feels like a useful skill" (SMSA Post).

While it may not be possible to entirely separate out attitudes toward mathematics and attitudes toward statistics, the following finding is good justification for why attitudinal research should consider both the global and the domain-specific perspectives. Students disliked statistics that involved mathematics topics that they did not like. Kelly made it clear that because of her struggle with computation, she disliked mathematics relying heavily on adding, subtracting, multiplying, and dividing without a calculator. Kelly (SMSA Post) wrote, "I dislike statistics that involves computation because it is hard." Kelly believes that doing statistics does not necessarily require that she do the kind of math that she does not like. It is important to understand Kelly's background attitudes toward mathematics. Otherwise, a dislike of computation could be misinterpreted as a negative attitude toward statistics.

The same could be said for Eric. He wrote, “I dislike statistics that involves math that I don't like” (SMSA Post). Eric previously stated that the math he does not like is everything but “easy algebra because is it hard and useless” (SMSA Pre). He wrote, “I like statistics that involves comparisons of people.” So for Eric, statistics that involves people-based data is likable provided analysis does not involve anything more complex than basic algebra.

Angie was also drawn to statistics of mathematical simplicity: “I dislike statistics that involves doing stuff other than simple math, especially probability” (SMSA Post). Others found probability to be difficult and unlikable. Mary (SMSA Post) wrote, “I dislike statistics that involves probability distributions because it is very hard for me to understand.” Carrie (SMSA Post) wrote, “I dislike statistics that involves probability, permutations and combinations because it is hard for me to understand.” Paula wrote, “I dislike statistics that involves probability, combinations and permutations, because it is more difficult to understand.” Recall the shift in the nature of instruction during the probability portion of the course. The textbook and corresponding assignments changed from a people-centered, real-world context to an answer-based, inanimate context. If students like statistics that is based on real-world scenarios involving people, it is not surprising that they did not like doing probability based on marbles and dice.

Confidence Doing Statistics

Students described confidence to do statistics through the SMSA, journals, and the second narrative. Two primary themes emerged: 1) Students are confident doing statistics that they like, and conversely, students are not confident doing statistics they do not like; 2) Students are more confident doing statistics than mathematics.

Confidence according to likes and dislikes.

Analysis showed a strikingly clear pattern between attitudes toward doing specific tasks in statistics and confidence to do those tasks. This pattern was not as evident with mathematics. The nature of the tasks tended to vary among students with the exception of a tendency to dislike probability, as previously described. In fact, each of the four students – Angie, Mary, Carrie, and Paula – described above as disliking probability also reported having low confidence to do probability. Angie wrote, "I'm not as confident I can do probability and upper level mathematics" (SMSA Post). Mary wrote, "I'm not as confident I can do probability, normal distributions, and find correlation coefficients" (SMSA Post). Carrie wrote, "In statistics, I'm really confident using equations but not as confident doing probability" (SMSA Post). And Paula wrote, "I'm not as confident doing probability, combinations, and permutations" (SMSA Post).

This pattern appeared with topics that students liked as well. Sam (SMSA Post) wrote, "I like statistics that involves constructing graphs because it is creative" and "In statistics, I'm really confident making graphs." Lisa (SMSA Post) wrote, "I like statistics that involves making charts on Excel because it's fun" and "In statistics, I'm really confident making charts and graphs in Excel." Paula (SMSA Post) wrote, "I like statistics that involves variations, standard deviations, bell curves, etc. because it was easy to understand for the most part" and "In statistics, I'm really confident finding variance, standard deviation, and using normal curves." Dana (SMSA Post) wrote, "I like Venn diagrams" and "In statistics, I'm really confident to do Venn diagrams."

Confidence doing statistics versus mathematics.

Some students were more confident about doing statistics earlier in the course than others. In the eighth week journal, students were asked, "How has your confidence in this class changed since the beginning of the course, if any? Please be specific. What factors have influenced these changes?" Mary wrote, "I've begun to spend more time on learning the book and applying it to our projects. This practice has given me more confidence in statistics" (Journal, Week 8). Paula wrote, "I feel more capable because I learn better with hands-on material" (Journal, Week 8). And Carrie wrote, "I feel more confident than I did in the beginning of the course because I have learned more. Learning out of the text book and actually going to The Agency has enabled me to learn more" (Journal, Week 8).

The magnitude of the change in confidence at the eighth week was moderate. Sam wrote, "My overall confidence with statistics has changed, but nothing major. I know the material fairly well. Studying the material has helped me be more confident with it" (Journal, Week 8). Referencing social comparisons, Angie wrote, "I think my confidence is mostly the same. It really helps that I'm comfortable with all the people in the class, so making mistakes doesn't bother me" (Journal, Week 8). Eric wrote, "My confidence has not changed significantly, though everything seems to be working well" (Journal, Week 8). Adam wrote, "My confidence is mostly the same but feeling like I know how to complete new tasks is good" (Journal, Week 8). Lisa wrote of her continued struggle with making meaning: "My confidence is about the same. However, I'm still struggling trying to learn the vocabulary from the chapters. I understand the definition; it's the putting and using them in the correct context" (Journal, Week 8). Kelly wrote, "I do not think my

confidence in my abilities to do math has changed during the class, though I am more confident to do some statistics" (Journal, Week 8).

By the end of the course, students' confidence had not increased drastically, though other students reported having greater confidence to do statistics than to do mathematics. Kelly wrote:

> I feel more confident, especially with qualitative statistics, which is more like thinking about topics and piecing information together. I am comfortable talking with people and drawing conclusions from written data. I guess in a way I feel more confident with statistics than other kinds of math because it does not seem to rest on computation. I am not confident with math assignments that rely on adding and multiplying a complicated set of numbers. (Narrative 2)

Similarly, Paula wrote:

> I'm not really all that confident to do statistics, however I am more comfortable with it than other types of math. I feel this way because it incorporates the things I feel most comfortable with -computation, calculator functions, making data instruments. (Narrative 2)

Lisa, felt more capable in statistics than in mathematics. She was drawn to the part of statistics that involves spreadsheet technology. She explains:

> I feel as if I am more confident with statistics than other kinds of math. I am able to look at different data and I am able to read and understand what was done. It is easier to read and understand surveys too. I'm really happy that I learned to use Excel. I think it will be useful in the future and I like working with computers. Through parts of the course, learning the vocabulary was hard and made me hesitate about doing statistics. But now, I feel as if I am more confident with statistics and am happy I learned it. (Narrative 2)

Improvements in confidence to do statistics over the 13 weeks of the course were not extreme. However, for students with a history of struggle in mathematics, any improvement in confidence is notable, especially given the likelihood that they will be required to take a course in statistics, or at least one involving statistics, in college.

The Role of Service-Learning

What are high school students' perceptions of the role of service-learning in influencing their confidence to do statistics? What are students' attitudes toward service-learning? What other service-learning outcomes do students report?

Processes associated with the service-learning project were monitored through student journals and through observations recorded by reflexive journaling. In this section, I summarize students' perception of the influence of service-learning on confidence to do statistics, students' attitudes toward service-learning, and additional outcomes associated with service-learning. Emerging themes are summarized in Table 5.

Table 5

Summary of Attitudes and Outcomes Regarding Service-Learning

Category	Theme
Service-Learning and Confidence Doing Statistics	Students perceived service-learning as positively influencing their confidence to do statistics.
Attitudes Toward Service-Learning	1) Students liked learning about other peoples' cultures and experiences; 2) Students enjoyed doing community service; 3) Students found the demands of the service-learning project to be challenging.
Personal and Social Outcomes	1) Students developed interpersonal skills through teamwork; 2) Students experienced a heightened sense of social awareness and responsibility.

Service-Learning and Confidence Doing Statistics

In the second narrative, given at the end of the course, students were asked to describe the experiences, both in and out of school that influenced their confidence to do

statistics. Intentionally, students were not directly asked to describe the role of service-learning in the development of confidence in order to avoid biasing the results to include this reference. However, on their own accord, students frequently wrote about the service-learning experience. There was one primary theme that emerged: Students perceived the service-learning experience as having a positive influence on their confidence to do statistics.

Paula describes her perception of influence of the service-learning project on her confidence to do statistics:

> I feel more confident in statistics because I can relate it to the outside world and understand it. I have seen how to put the skills I've learned to use. The service-learning aspect also helped in that I saw the impact of my math that I did and understood. (Narrative 2)

Eric also believed that the application of statistics to real life scenarios was key. He was driven by the impact of his work on the lives of actual people. Eric describes how the combination of getting good grades and doing the service-learning project helped him to gain confidence:

> To do statistics is to be able to understand the concepts which make up statistics and be able to apply them to actual real life statistics. If you cannot apply them to real life statistics then a big part is missing.
>
> For me, working with The Agency has helped me understand how to apply the concepts of statistics to real life people, which has helped me become more confident. When I see who my work is affecting I am more motivated. The thing that has caused me to gain the most confidence is my test scores in this term and seeing the people who my work is affecting. When I see real people who I am helping I am encouraged to do more statistics. (Narrative 2)

Carrie explains how her confidence was positively influenced by an increase in knowledge about statistics through regular course work as well as through direct interaction with The Agency and service-learning project activities:

> One factor that has influenced my confidence to do statistics is the work that we have done in math class…Learning more about statistics and how to work with statistics has increased my confidence.
>
> Another factor that has influenced my confidence to do statistics is going to The Agency and doing projects for them. Going to The Agency and the projects for them gave me a chance to work with real life statistics. Working with The Agency gave me a chance to learn about and work with statistics in another way, which was nice….I think I learned a lot by visiting The Agency and refugee families and understanding how The Agency's program works. I also learned a lot more of the fundamentals of statistics and learned how to do more statistics-related problems. …The people at The Agency explaining how all of the programs work has helped me feel more confident in my ability to help at The Agency. (Narrative 2)

Service-learning provided an opportunity for performance mastery experience in a real setting that required that students put their skills to use in a way that benefited other people. Students felt accountable for their work beyond the normal classroom requirements. For Adam, knowing that The Agency was depending on his work in order to make decisions that would impact others was the motivating factor. Adam wrote,

> In relation to this course something that helped make me feel more confident about statistics is helping the refugees at The Agency. I think that when you are doing a project to help an organization like The Agency, you have to feel confident in your work and knowledge of statistics. There are people that need to know how well a donating program worked in order to decide if they continue it or not and what to do with the donations. This is how the Lighten The Load project helped my confidence with statistics. (Narrative 2)

Other students agreed that having someone else depend on their work was motivation to overcome what they describe as "senior-itis," or a tendency to slack off during their senior year. This concept was explored in the member checking session:

> Leong: Third, knowing that The Agency was depending on your results helped to keep you motivated. Is this true?
> Group: Concur
> Leong: So, if we had done a similar project, but no one else was going to see the outcome except for me and your classmates, do you think you would have put as much energy into it?
> Adam: I know for me, I probably wouldn't have. But that's just me. I admit I

have "senior-itis."
Brad: Yeah, me too.
Others: Concur (Member Checking, May 4th)

Angie believed that the statistics she had learned was different from advanced placement statistics. She explains:

> I still feel like I have a hard time explaining to people when they ask what my class is about. I feel like we learned about different statistics than like what the AP statistics class does. I guess I'm still not that confident in doing statistics, though in our project I was able to do all the stuff we were asked to do. (Narrative 2)

Angie was correct that the course did not cover the same topics that the advanced course did. While her confidence to do more challenging statistics was low, she maintained confidence to do the more introductory statistics that was incorporated in the service-learning project: "In statistics, I'm really confident doing what we did for our project but not as confident doing most everything else" (SMSA Post).

It is difficult to change high school students' beliefs about mathematics. However, these findings suggest that it may be possible to positively change students' confidence beliefs utilizing models like service-learning. In addition, while the same may be true of other kinds of service-learning projects, the nature of this particular project elicited positive attitudes from students.

Attitudes Toward Service-Learning

Overall, students maintained positive attitudes towards the service-learning project. Three primary themes emerged: 1) Students liked learning about other peoples' cultures and experiences; 2) Students enjoyed doing community service; 3) Students found the demands of the service-learning project to be challenging.

Learning about others' cultures and experiences.

Community service was not a new activity for these students, but in the context of a math class, it was an exciting, yet unfamiliar, concept. Adjusting to the idea took some time for some. For example, in the second week journal, Mary's response to the question, "What challenges lie ahead?" was as follows:

> …learning about other cultures and being able to relate to them and connect their issues with my math class. It just seems odd that we're using people coming from such horrible situations in our statistics class. I'm glad that we are helping but it just shows how odd our world is when our "class project" can mean the world to a whole family or something. I always thought that projects were a poster board with printouts or something. This seems a lot more important but also strange. (Journal, Week 2)

By the fourth week, Mary was making connections between statistics concepts and the service-learning project: "This week, I worked in the textbook of statistics and related it to the work we're going to do with The Agency" (Journal, Week 4). By the seventh week, this connection was even stronger: "I like learning stuff that can apply to my project and then getting to do it myself instead of just watching in class" (Journal, Week 7).

Others were more at ease with the idea of service-learning and statistics earlier on. For example, in the first week, Carrie wrote, "This is a very interesting project and I am excited and looking forward to doing it" (Journal, Week 1). Also in the first week, Lisa wrote:

> I learned that I am able to help others using statistics. There are a lot of people who need help in the world. A lot of people put a lot of time and effort into helping those who are less fortunate. I've actually known this but now, through this class I'm taking action. (Journal, Week 1)

In the second week, Angie wrote:

> Statistics will help me formulate the information to help The Agency with knowing if a program is worth their time and money. It was important to get background on the both the refugees and The Agency because those are what we're working with and on. (Journal, Week 2)

Sam wrote, "We learned how statistics is going to apply to this project specifically" (Journal, Week 2) and "The transitions from one chapter to another in our book are working well and everything seems to be fitting into the course well" (Journal, Week 6).

Regardless of students' initial level of comfort with the idea of the service-learning project, students liked the context of the project and the background learning associated with it. In the second week of the course, several visitors came to talk to students about the project and its background. I noted these events in my reflexive journal:

> Yesterday, two students who volunteer with The Agency came to class and spoke about their experiences. Today, three representatives from The Agency came and talked more about what they do and their needs regarding our project. One of the representatives is a former refugee and she shared her personal experience. She told us about the difficult decision she made to leave her family behind in Somalia so that she could become an anchor for them in America, and eventually try to bring them here. The students appeared interested and engaged. They asked good questions and listened intensely. (Reflexive Journal, February 9, Week 2)

Students' journal responses for that week indicated positive attitudes. Kelly wrote, "I like learning about other cultures. I enjoyed having the speakers." (Journal, Week 2). Lisa wrote, "I think it's wonderful that people are willing to give back to the community and others outside of the community" (Journal, Week 2). And Carrie wrote:

> Hearing the stories from the speaker who came and talked to our class really makes me appreciate what the refugees have gone through and are going through and makes me appreciate what I have. Hearing the speaker's stories also makes all of the refugee stories a lot more real. I learned that I am really interested in the refugee program and hearing stories from refugees. (Journal, Week 2)

The following week, I took the students to see the movie, *Hotel Rwanda*, that depicts events pertaining to the genocide that took place there in 1994. Students eagerly anticipated this event. Brad wrote, "I am excited to see *Hotel Rwanda* this coming week" (Journal, Week 2). Dana wrote:

> I'm really psyched. I think our class should definitely see *Hotel Rwanda*. Instead of seeing refugees as the poor people that the US is saving from their terrible living conditions, *Hotel Rwanda* shows the individuals as heroes, making it out of a seemingly impossible, terrible situation. (Journal, Week 2)

Following the viewing of the movie, I noted students' reactions in my reflexive journal:

> Today, I took the class to see the movie, *Hotel Rwanda*. After we watched the movie, we had a discussion about genocide and we talked about how the movie impacted us. The students expressed gladness that their project would help refugees. (Reflexive Journal, February 18, Week 3)

Students were clearly expressing signs of increased levels of social awareness and responsibility. Lisa explains in her journal:

> I learned of all of what was going on in Africa. I knew things were going on but I never looked into it. I am more aware of the situation and it is now something that I can't pretend I don't know is going on. I thought the movie was really good and I'm happy that I'm aware of what's going on and that this class is helping with refugees who come from similar and different situations. (Journal, Week 3)

Kelly was moved by what she saw as well:

> I was reminded how fortunate I am that I can walk down the street without fear of being killed. Life would feel so different and more challenging if you never felt safe. I was also reminded how much more power I have simply because of my ethnicity and the country I was born in. I also was reminded about the horrors of genocide and how in general the West is prejudice against the rest of the world. (Journal, Week 3)

Mary was motivated and inspired by the movie to become more involved with The Agency:

> I learned about the Hutu vs. Tutsi problem in Rwanda and was really disturbed by it and how the U.S. and other countries did nothing. I was really affected by the movie but it made me feel a little less ashamed to know more about the genocide. I felt sick so many times during the movie because I knew I would have been one of the white people freaking out and being bussed out of the war zone. I am glad I am educated on the genocide in Rwanda. The movie was really great and it made me want to be more active in refugee groups like The Agency so I can help.
> (Journal, Week 3)

It was important that students understand the culture of The Agency's clients and feel connected to the community through our class project. Having visitors to the class, doing background reading and research, and seeing films like *Hotel Rwanda* were all for this purpose, but the best way for students to truly understand the people their work would impact was to spend time with them. Therefore, students were required at first to spend a minimum of three hours volunteering with The Agency. Because of scheduling conflicts, this requirement was later adjusted to alternatively allow for a writing/advocacy option. All but two students completed the service with The Agency. While there, students helped to organize the clothing closet and storage room. They also spent time visiting with refugee families to try and make them feel welcome.

Doing community service.

Early in the term, Paula and Carrie came with me on an optional visit to The Agency. Carrie had to leave early, and did not get to join Paula and me when we visited with a refugee family that had only been in the United States a few weeks. Nonetheless, Carrie was inspired by what she experienced. She wrote:

> I thought it was really interesting and fun going to The Agency and hearing more about their program and how they do things. I am disappointed that I was not able to go visit the family, but I look forward to helping out there. (Journal, Week 5)

The family that Paula and I visited was incredibly welcoming and seemed grateful for the company. I recall the experience in my journal:

> Yesterday was amazing! After school, I took two students over to The Agency. Carrie could only stay for a short while, but Paula and I went to visit a refugee family. They were an Afghanistan family of eight. The children ranged in age from 9 to 22 years old. They were so happy to have some human contact and interaction. We delivered some items for the children. They showed us how to write their names in their native language. A translator was able to help us communicate. When we left, Paula said, "That was awesome! I have so much to tell everyone tomorrow. They missed out!"
>
> Today, I gave Paula an opportunity to share with the class what she experienced. She shared with the same enthusiasm she had yesterday. Other students seemed eager to visit The Agency too. (Reflexive Journal, February 24, Week 4)

Mary expressed this eagerness in her journal. She wrote:

> I'm really excited to meet a refugee family and try and understand how hard it must have been for them to have left everything thy knew and adjust to a whole new culture and life. I wish I would have been able to come to The Agency. I'm sure that would have really inspired me to get more involved in my yard sale project. I can imagine how powerful going to talk to a refugee family would have been. (Journal, Week 4)

Paula was excited about the service-learning project from the start, but her enthusiasm after this visit was even greater. The difference academically and attitudinally was remarkable. I noted this change in my journal as well:

> Paula was practically silent last term and performed near the bottom of the class. Based on her first narrative, she has very low confidence in math. This student has since come alive in class and is leading discussions about refugees as well as the readings and problems from the textbook. Perhaps other students would share this enthusiasm had they been able to come along for the first visit to The Agency. I'm interested to hear their reactions once they've had a chance to complete their service. (Reflexive Journal, February 26, Week 4)

Other students reported positive and powerful experiences serving with The Agency. Eventually, Carrie was able to go back and spend time with a refugee family. She wrote, "Everything seems to be working well and the trip to The Agency especially

went really well. I really enjoyed meeting the family" (Journal, Week 7). Kelly and Angie visited a 19-year old refugee woman with a newborn infant. Both students expressed a heightened sense of social awareness by this experience. Kelly wrote:

> Visiting The Agency went well. I was really surprised to see a girl my age with a baby. I know that is not so unusual but it still surprised me. I learned from the young woman that she knows about seven languages. I was reminded how students in the U.S. are not forced to know anything other than English. I learned that I am ignorant to how differently people in other parts of the world live. (Journal, Week 7)

The closeness in age between Angie and the young refugee woman was significant for Angie. She wrote:

> It really impacted me in the girl's place that we met. She moved here about seven months ago, and had a baby three weeks ago. She turns 19 in May. I turn 19 in April. I know already how privileged I am, but on Friday I was reminded again. (Journal, Week 7)

Not all students were as expressive about the service experience as Angie and Kelly, but during the member checking session, other students agreed that it was enjoyable.

Challenges of the project.

Lisa and Dana were the two students that chose the alternative writing/advocacy option. They decided to watch the documentary film, *The Lost Boys of Sudan*, write a reaction paper, and hold a petition signing in the high school urging the U.S. government to intervene against the violence in Darfur, Sudan. They each told me that they preferred to do the service because they thought it would be a meaningful experience, but felt restricted by time and transportation issues. Early on, Lisa wrote that she felt challenged to "find the time to get the community service done" (Journal, Week 1). Later, she wrote, "Putting effort into the projects in order for that to get done, doing math homework, other school work and swimming outside for school is really hard for me. So I'm trying to keep

it all together" (Journal, Week 3). Dana was also initially concerned because of multiple commitments. She wrote:

> It's going to be a challenge to find time to do projects for the class outside of school. My soccer coach won't let me miss anything, so I'm worried about that. It's also going to be hard for me to be really organized. I hope that our group can use people's skills evenly. (Journal, Week 2)

As the course progressed, Dana's concerns persisted:

> The execution of our project is big. I'm still worried about my time. Soccer takes over my life once a year. I really want to put in the hours and not cop out and do the other options, but I don't know if I'll be able to. (Journal, Week 4)

Other students worried about managing the demands of the project as well, even though they expressed positive attitudes toward learning about other peoples' culture, toward service with The Agency, and toward learning to use statistics while helping others. Carrie wrote, "Proceeding with the projects, getting the projects organized, and carrying out the projects might be challenging, but I think it will be fun also" (Journal, Week 2). The out-of-class time required for the project posed challenges to students, but ultimately, it was manageable. In a member checking session, I discussed this issue with them:

> Leong: So I also noticed that there were some cons to the project. Here's what I have. First, the project required a lot of time and work outside of class.
> Dana: Definitely. It was hard for me to keep up with all the other things I have after school, plus the homework.
> Leong: Ok. Do others feel the same or different?
> Paula: Kind of. It wasn't that bad, though, because we had a lot of class time.
> Angie: Yeah, but our project required a lot of driving around and took up some weekends.
> Leong: Ok. What about the Light The Load group? Were you able to manage the out of class load of the project?
> Sam: Yeah, it wasn't that bad because we only had two places to go to. I guess if we had more locations it might have been more difficult.
> (Member Check, May 4, Week 13)

In anticipation of this reaction, at the beginning of the course, I explained that the project might require coordinating time outside of class, though I would be giving them class time as well. Since students live various distances from school and have different after school schedules, they were allowed to choose a group that would work best and decide on a team leader to be a point person. The Yard Sale Team was Kelly, Carrie, Mary, and Angie (team leader, Kelly), the Lighten The Load Team was Sam, Brad, Eric, and Adam (team leader, Sam), and the Operation Bake Swap Team was Dana, Paula, Lisa, and an additional student that chose not to participate in the study (team leader, Dana). (The grouping of an all boy and an all girl team was not intentional.) Despite the freedom to choose a team that best met time and location requirements, students were concerned about coordinating groups and maintaining momentum to meet project deadlines.

As the course progressed and students saw that they were able to overcome these hurdles and that I followed through on my promise to allow class time for group work, this worry tended to subside, but at first it was widespread. Lisa wrote, "The only thing that I am worried about now is my group being able to organize our work and have everything done on time" (Journal, Week 2). Angie wrote that her challenge was "getting the time to work on the project with group members because we're all so busy" (Journal, Week 2). Similarly, Paula wrote, "I feel as though the groups may have scheduling issues along the way, so doing the actual work may be a little more difficult" (Paula, Week 2). Carrie's challenge was "getting organized with the activities that we will do with The Agency and continuing with our projects" (Journal, Week 4). Kelly felt pulled in two directions at first. She wrote:

> Having class time to working on our project is very helpful, but it feels like we are working on two unrelated things right now - math and the refugee project. Finding time to complete all the components of our group project will be challenging. (Journal, Week 4)

One week, the project was particularly demanding for Kelly. She wrote, "I spent a lot of time this weekend on math class because of visiting The Agency and doing yard sale shopping" (Journal, Week 7). As team leader, Kelly felt pressure to manage the other members of her team. She wrote, "Completing my group project will be challenging. It is also challenging to get my group members to bring to class the items they have bought in the yard sales" (Journal, Week 8). (Her group members did bring in the items.) Kelly learned about teamwork and people management. Other students did too. This is one of the outcomes of service-learning that I discuss next.

Other Service-Learning Outcomes

Students' journal entries and observations uncovered additional service-learning outcomes. Two primary themes emerged: 1) Students developed interpersonal skills through teamwork, and 2) Students experienced a heightened sense of social awareness and social responsibility.

Interpersonal skills and teamwork.

The nature and scope of the project required significant team effort. I was clear from the beginning that I expected every student to share project responsibilities, though exactly how that would be done was left up to them. At the end of the course, each student completed an evaluation of themselves and each of their teammates that constituted 10% of their final grade. Students were aware of this up front.

Despite initial apprehension towards coordinating a team effort, students demonstrated exceptional abilities in this regard. In a member checking session, students expressed pride in their teamwork:

> Leong: Okay, I also noticed that you learned some things about teamwork. Is that right?
> Angie: Yes. I really liked working in groups. I think our group worked really well together.
> Paula: Yeah, our group did a good job sharing responsibilities. We had a good team leader.
> Sam: I think using email helps a lot with communication.
> (Member Check, May 4, Week 13)

Lisa's confidence in her teammates did not start out solid. In the second week, she wrote, "I have to learn to trust my other team members to get their work done" (Journal, Week 2). But by the third week, she had already settled into a productive pattern with her team. She wrote, "I helped my group to come up with an evaluation plan for our Operation Bake Swap. We worked together to make sure that the information was clear and met the requirements" (Journal, Week 3).

Paula approached this issue of teamwork by thinking about how she would establish herself within the team based on each member's skills. She wrote, "My next step is to define my position in my group and figure out how I can make the biggest contribution to my group as possible" (Journal, Week 3).

Dana was pleased with the efforts of her team and regretted missing an important class day. She wrote, "I think that our group works quite well together. Paula and Lisa have great gumption. I missed a day so I didn't get to really lead as much as I should have because I missed the day that we started the project" (Journal, Week 3).

As team leader, Sam had an approach similar to Paula's. He wrote, "I am learning about how my team members do work and the most efficient way to get them to do it" (Journal, Week 2). This worked well for Sam's team. Brad wrote, "The teams are working well. No suggestions for improvement" (Journal, Week 3). Later in the course, Sam wrote, "Most people seem to be keeping up with their work in a timely way" (Journal, Week 7). Sam's team did learn a valuable lesson one day when they missed a project deadline. Sam's teammate Eric explains, "I learned that when other people rely on each other for a project it is not always the best idea to have only one person with the information we need" (Journal, Week 10).

Kelly's group also worked well as a team. Kelly played an active role in coordinating and planning team efforts in advance. She wrote, "Angie and I need to plan a time to go to yard sales next week" (Journal, Week 6). Angie had faith in Kelly early on. She wrote, "I think everything's working pretty well. Kelly should be a good team leader" (Journal, Week 3). Carrie agreed: "My group seems to be working well together. We seem to be getting along well and splitting the work well" (Journal, Week 3).

Social awareness and responsibility.

In addition to developing interpersonal skills through teamwork, students became more socially aware and responsible. Social awareness differs from social responsibility by a feeling of being compelled to take action. Polk (n.d.) identifies nine elements of social responsibility as:

1) recognition and acceptance of the consequences of each action and decision one undertakes,
2) caring attitude towards self and others,
3) a sense of control and competence,
4) recognition and acceptance of individual and cultural diversity,

> 5) recognition of basic human rights of self and others,
> 6) the ability to be open to new ideas, experiences, and people,
> 7) understanding of the importance of volunteering in social and community activities,
> 8) ability to engage in experimentation with various adult roles, and
> 9) development of leadership, communication, and social skills. (para 3)

Several examples that demonstrate the ways in which students became more socially aware and responsible have already been described in reference to students' reactions to class visitors, seeing *Hotel Rwanda*, and doing service with The Agency. Students wrote about other instances of being impacted in this way in journal entries.

From a social awareness perspective, students learned about their local community as well as the broader, international community. For example, Brad wrote:

> I learned about the refugee community in Atlanta. I learned about refugees both in their countries and in the United States. I felt that it was important because I am bound to encounter refugees and it's always best not to be ignorant when talking with and interacting with people in your community. (Journal, Week 2)

Brad's awareness continued to develop after completing his service. He wrote, "I learned a lot about both myself and others by visiting the family when at The Agency. I learned a lot about the situation of refugees first hand. I also learned some about the families' lifestyles" (Journal, Week 7).

Sam wrote, "I learned about refugees from other countries and how little the United States does for them" (Journal, Week 2). Paula expressed the same idea. She wrote, "This week I learned that on a big scale, the U.S. does not adequately assist in community efforts" (Journal, Week 2).

Students developed an awareness of refugee issues as well as community response and involvement in that regard. Angie wrote, "I learned more about the refugees coming here, and about The Agency. I learned the difference between an immigrant and

refugee also" (Journal, Week 2). Mary wrote, "I learned The Agency does work on helping people from other countries and there are parts of our government and community that are willing to help other needy people" (Journal, Week 1). Adam learned "that refugees who resettle in America do not want to stay and await being able to come home" (Journal, Week 2). This was significant to Adam because he no longer believed the stereotype "that all refugees are so pleased with America compared to their home country" (Journal, Week 2).

Carrie and Dana were struck by how much they did not know about refugees. Dana wrote with intensity:

> I learned how ignorant I am about immigrants and refugees and how little I'm around them. People will go through a lot to come to the country I take for granted. We are ignorant of the struggle that people go through to come to our home. Just thinking about refugees and how our society makes it so easy to ignore them. I could go through a whole year and not see a refugee. (Journal, Week 2)

Carrie's reaction was more moderate, though she was also enlightened by her newfound awareness. She wrote:

> I learned that I really do not know very much about the areas and conditions in the places that the refugees are coming from. I learned about some of the conditions that the refugees are living in. I learned that there are organizations in the community helping refugees, and specifics about what these organizations do. (Journal, Week 1)

Carrie expressed an appreciation for The Agency's work: "What I learned shows how much The Agency does for the families that they help and how important The Agency's help is to the families" (Journal, Week 7).

Beyond a heightened sense of social awareness, students expressed a genuine desire to reach out and lend a hand to those in need, thus demonstrating a sense of social responsibility. For example, Carrie wrote, "What I learned shows that the refugees that

we are going to be hopefully helping really do need our help. My next steps are learning more about the refugees and about how the program works, and trying to help in whatever way I can" (Journal, Week 1). Mary wrote, "My next steps are to research more of current refugee situations and read about the problems and learn how I can help" (Journal, Week 2).

Sam and Brad also expressed a desire to take action. Brad wrote, "I learned that I was definitely interested in helping out with refugees" (Journal, Week 2). And Sam wrote:

> I hope that what I am learning this term will affect what I do for other people in the future and the ways in which I participate in efforts to help people that are less fortunate than I have been. (Journal, Week 2)

In a member checking session, students stated that they would utilize their awareness to educate others and to value what they have:

> Leong: So, what do you plan to do with this new knowledge about refugees?
> Dana: I think it helps to be aware of what's going on out there so you can help educate other people and not be ignorant.
> Kelly: It also makes you appreciate what you have and not take things for granted.
> Group: Concur
> (Member Check, May 4, Week 13)

Dana described a way to become active externally, while Kelly described more of a change within.

Also in the member checking session, I explored whether students had a sense of how they can use statistics to become socially responsible. I recount the discussion:

> Leong: Can you think of any way you can use statistics to make a difference in the world?
> Group: Silent…pause
> Sam: I guess if I worked for a company that helped people like refugees, I could use statistics to see what are their needs and how the different

programs are working.
Leong: Ok. Are there any other ways?
Brad: Well, there are statistics in the news and on T.V. and you have to be able to understand what they're talking about.
Leong: What kind of statistics have you seen in the news?
Brad: Well some are about sports and stuff, but also about war and how many people have been killed.
Leong: Okay, so how might you use what you know about statistics to make a difference in the world when you hear these statistics on the news?
Brad: It's important to understand what they're talking about so you can form your opinion based on what you think is biased or not.
(Member Check, May 4, Week 13)

Brad's response coincides with the general belief that statistics is useful for informed decision-making. He is able to conceptualize how this decision-making can extend beyond what impacts him on just a local level, but how the media, in particular, can impact what he thinks about issues that are more global in scope, like war.

These findings have important implications for educators, especially those considering implementing service-learning in their own classrooms. The findings also have broader implications for the mathematics and statistics education research community. In the next and final chapter, I discuss conclusions that can be drawn and the implications of the study from both local and public perspectives. Limitations of the study and future recommendations are also provided.

CHAPTER 5

SUMMARY AND DISCUSSION

This chapter begins with a brief summary of the study. A discussion of the conclusions with regard to the research questions follows. Next, the implications of the study for researchers and educators are outlined, and then limitations of the study are discussed. This discussion is followed by suggestions for future research. Finally, closing statements about the study as a whole are provided.

Summary of the Study

Despite agreement among researchers about the powerful influence of attitudes and beliefs on the development of students' mathematical knowledge base (Leder, Pehkonen, & Törner, 2002), relatively little is known about these constructs in statistics education. One of the goals of this study was to determine the extent to which attitudes and beliefs regarding mathematics parallel with attitudes and beliefs regarding statistics.

Statistics education is growing in momentum as an integral part of the K-12 curriculum. In high school, besides advanced placement courses, stand-alone, introductory statistics courses are becoming more common. Considering that students' attitudes toward mathematics tend to decline most rapidly during middle school and continue to decline in high school (Ma & Kishnor, 1997), it is important to determine how best to monitor and improve high school students' attitudes and beliefs regarding statistics, in spite of potentially less positive ones regarding mathematics.

One instructional model that is receiving growing attention in statistics education is the service-learning model. In a service-learning model, academic learning is integrated with community service and structured reflection. In other fields, like the social sciences, research about service-learning has shown to positively influence personal and social outcomes like students' sense of social-responsibility and self-efficacy (Eyler, Giles, & Grey, 1999). Therefore, it is logical to anticipate similar outcomes in statistics education. However, the body of research in this area is sparse, particularly with regard to high school students.

There were two main purposes of this study. The first purpose was to determine the relationship between high school students' attitudes and beliefs regarding mathematics and those regarding statistics. Because participants in the study were taking a first course in statistics, understanding this relationship is essential in order to discern between attitudes and beliefs regarding mathematics that carry over to statistics and newly developed attitudes and beliefs regarding statistics. The second purpose was to investigate high school students' perceptions of the influence of service-learning on the development of their own attitudes and beliefs. The research questions that guided the study were:

1. What are high school students' attitudes and beliefs regarding mathematics and statistics, respectively? In particular, what were students' general beliefs about the nature and utilization of mathematics and statistics, beliefs about what it means to *do* mathematics and statistics, and beliefs about confidence to do mathematics and statistics?

2. To what extent do high school students' mathematics-related attitudes and beliefs parallel their statistics-related attitudes and beliefs?

3. What are high school students' perceptions of the role of service-learning in influencing their confidence to do statistics? What are students' attitudes toward service-learning? What other service-learning outcomes do students report?

Participants were 11 high school students in a slower-paced, introductory statistics course of which I was the teacher. The course was centered on a semester-long service-learning project through which students conducted a statistical analysis for a community organization (referred to as The Agency) that provides assistance to refugees resettling in the community. The three primary modes of data collection were journals, written narratives, and open-ended surveys (Survey of Mathematical and Statistical Affect). Narratives and surveys were administered at the beginning and the end of the course; journals were collected roughly weekly. Observations and reflections were also recorded regularly in my researcher journal.

Utilizing qualitative, action research methodology, I approached the research through an interpretivist lens as teacher-researcher. Extensive efforts were taken to establish trustworthiness criteria of credibility, dependability, transferability, and confirmability (Lincoln and Guba, 1985). Analysis was consistent with procedures according to LeCompte and Schensul (1999a), employing item, pattern, and structural levels of analysis. Findings are substantiated by illustrative quotations from students as well as from my journal and member checking notes.

Conclusions and Discussion

In the previous chapter, students' attitudes and beliefs regarding mathematics, statistics, and service-learning were described. In this section, additional conclusions are discussed regarding parallels between mathematics- and statistics-related attitudes and beliefs and regarding service-learning-based statistics. I begin with a summary of the findings thus far.

Summary of Attitudes and Beliefs Regarding Mathematics

Collectively, students' mathematics-related attitudes and beliefs reflected an unimaginative and rather dull perspective of mathematics. Since U.S. students' attitudes and beliefs regarding mathematics tend to decline most rapidly in middle school and continue declining in high school (Ma & Kishnor, 1997; Wilkins and Ma, 2003), these students are not different from the general population. Students' conception of doing mathematics was a school-based, "number-crunching," automated process that requires memorizing formulas. However, students believed that for those few people who are capable of becoming mathematicians, which does not include them, mathematics could be an explorative and highly inventive process. On the other hand, students' envisioned personal uses of mathematics were more practical and required only basic skills.

Students' mathematical aspirations were low; they only liked doing mathematics that is simple and easy to understand. Further, the kind of math that students reported as likable, that is, mathematics that has clear applications to real life, had little correlation with students' descriptions of doing mathematics in the classroom.

Students wrote vividly about experiences that influenced their confidence to do statistics. Some students told stories of encouragement from teachers and family while

others wrote about memories from early childhood of feeling ridiculed in class. Some students wrote about the pressure of social comparisons. Others expressed relief from pressure by taking the slower-paced route. Some wrote about performance mastery experiences inside the classroom and others wrote about instances doing mathematics in real life. Self-efficacy literature does not distinguish between classroom-based versus real life performance mastery experiences as having greater or lesser influence on the development of self-efficacy. The literature does say that out of other documented sources, performance mastery experiences have the greatest influence on self-efficacy beliefs through "perseverant effort" in "overcoming obstacles" (Bandura, 1994, pg. 2). However, the context within which these experiences occur could have additional influence and meaning. While students referenced a mixture of positive and negative experiences in multiple settings, cumulatively, students' confidence to do mathematics was generally low.

Summary of Attitudes and Beliefs Regarding Statistics

Students' attitudes and beliefs regarding statistics were less dismal than those regarding mathematics. The literature suggests that statistics projects that utilize real or student-generated data will have a positive effect on statistics-related attitudes and beliefs (Fillebrown, 1994, Holcomb & Ruffer, 2000,Mackisack, 1994, Smith 1998). The key is in establishing personal relevance of statistics (Mvududu, 2003). Again, the findings of this study are consistent with the literature.

Generally, students still believed that statistics involved numbers, but the numbers were representative of something beyond just an answer to a problem. There was some inherent meaning behind the numbers and statistics is about seeking to understand that

meaning. Students also believed that they could do statistics using a limited amount of mathematics. Correspondingly, students reported that they dislike statistics that involves complex mathematics, like probability, and that they are not confident about doing this kind of statistics.

Students believed that doing statistics means collecting, analyzing, and interpreting data about people. Students believed that the act of doing statistics described as such is useful. Many believed they would use statistics to do more research later in life. Students also described how knowledge of statistics would be useful later for making decisions, whether financial, political, or career oriented.

Students did not believe that doing statistics included writing evaluation plans. The process of planning to do research, which involved significant amounts of reading and writing, was a foreign concept to students. Based on students' beliefs about what it means to do mathematics, it is reasonable to assume that reading and writing is not something that students associate with doing other kinds of mathematics either.

Students' concept of doing classroom statistics aligned with their concept of doing statistics in real life. Furthermore, students viewed the statistics that they do to be practically the same as the statistics that statisticians do. Statisticians do the same work just on a larger scale.

Students reported that they like doing statistics that involves people and that they have confidence doing statistics that is situated around real-life scenarios. While students did not report extreme improvements in confidence to do statistics, they did report greater confidence to statistics than other kinds of mathematics.

Parallels Between Mathematics- and Statistics-Related Attitudes and Belief

> *To what extend to high school students' attitudes and beliefs regarding mathematics parallel with those regarding statistics?*

Having established an understanding of students' attitudes and beliefs regarding both mathematics and statistics, it is now possible to examine them for convergences and divergences. The parallels between students' mathematics- and statistics-related attitudes and beliefs are summarized in Table 6. Interestingly, students' attitudes toward mathematics tended to parallel attitudes toward statistics, but the same does not hold for beliefs. To illustrate, first consider students' general beliefs regarding mathematics and statistics.

Students believed that mathematics was about manipulating or "crunching" numbers whereas students believed that statistics was about finding meaning behind data, or understanding the implications of the data within a given context. The first belief is more automated in nature while the latter requires deeper conceptualization. It would seem easier to give an automated response than one that requires thought or synthesis, yet students believed that mathematics was difficult. This belief may have to do with the particular sample because the course itself was designed for students that tend to struggle with mathematics for various reasons. Some students believed that doing statistics was easier than doing mathematics. This belief may stem from the general belief that the mathematics needed to do statistics is relatively simple, only including basic arithmetic and graphing.

Table 6

Parallels Between Attitudes and Beliefs Regarding Mathematics and Statistics

	Mathematics	Statistics
General Beliefs About …	1. Manipulating numbers to get correct answers 2. Can be difficult to understand 3. Useful on the job and for routine daily activities	1. Understanding meaning and representation of numerical data 2. Can be done using basic, easy math 3. Useful for doing research and more statistics
Beliefs About Doing …	1. Practicing problems from the textbook using formulas and equations 2. Classroom mathematics is different from real-life mathematics 3. Classroom mathematics is different from mathematicians' mathematics	1.Collecting, analyzing, and interpreting data about people 2. Classroom statistics is the same as real-life statistics 3. Classroom statistics is the same as statisticians' statistics
Attitudes Toward …	1. Like mathematics that applies to real life 2. Like mathematics that is simple	1. Like statistics that applies to real life 2. Like statistics that involves simple mathematics
Confidence Doing …	1. Low confidence influenced by performance mastery experiences, social comparisons, teachers, and family	1. Moderate confidence influenced by service-learning experience

Students believed that both mathematics and statistics are useful, but the way in which they believed each is useful differs. Students listed practical applications of mathematics on the job, for financial management, and for other routine activities. The uses that students described for statistics were less about day-to-day applications. Instead, students believed they would use statistics to do more statistics. In other words, they believed that they would use statistics-type skills to conduct research projects in the future, in college and otherwise. Students also believed that statistics would be useful for making informed decisions on a personal and local level, e.g. when purchasing products or reading sporting news, as well as on a more global level, e.g. filtering media reports on social and political issues.

Next, consider students beliefs about doing mathematics versus statistics. These beliefs tended to align with students' general beliefs about mathematics and statistics, respectively. Students believed that doing mathematics is about working practice problems using formulas and equations in order to get a correct answer. This is what students mean by "number-manipulation". This belief is relevant to students' present status, that is, as high school students. However, students believed that later in life, doing mathematics would correspond to what they described as uses of mathematics, namely, job-related and day-to-day uses. Students' current version of doing mathematics in the classroom did not correspond to students' version of doing "useful" mathematics later in real life. On the other hand, students made no distinction between doing statistics now versus in the future. Students believed that doing statistics meant collecting, analyzing, and interpreting data on a sample of people. Students engaged in these same activities in the classroom, and according to them, doing statistics defined in this way was useful.

Students also believed that the mathematics mathematicians do is different from what they do in terms of exploration as well as complexity. Furthermore, they believed that the mathematics of a mathematician is beyond what most people are capable of understanding. In comparison, students believed that the statistics statisticians do is similar to what they do except greater in scope. One additional belief held by students in relation to the particular project they were assigned was that doing statistics did not include writing evaluation plans. Students struggled with the process of planning to do statistics, which required reading and writing instead of computing. Again, this belief corresponds to general beliefs about mathematics and statistics, both of which, according to students, involve doing something with numbers or data.

Students' attitudes toward mathematics closely paralleled attitudes toward statistics. Students did not enjoy doing mathematics they perceive to be complex, abstract, or time-consuming. Similarly, students disliked doing statistics that involves this kind of mathematics. However, because the course was an introductory course, it did not require deeply complex mathematics. The most complex concepts covered were in the probability section and students did have difficulty with this. Accordingly, students frequently reported disliking probability. Another attitude that students shared toward mathematics and statistics was a like of topics that have direct applications to real life and are easy to conceptualize. In statistics, this means doing statistics that involves real life scenarios and people.

Finally, the data yielded interesting findings pertaining to students' confidence to do mathematics and confidence to do statistics. Students described feeling confident doing mathematics with which they had positive performance mastery experiences in the

classroom as well as in real life. Students described feeling confident doing statistics that they like to do. But the statistics that students like to do involves the same kind of mathematics that they feel confident doing, namely, mathematics involving simple procedures and real world applications. Thus, the connection between students' confidence to do mathematics and confidence to do statistics is established.

Students described other experiences that influenced their confidence to do mathematics as well. Some described how social comparisons had a negative influence, though this was not true for all. They also described how teachers and family have positively and negatively influenced confidence. Students did not reference these same factors when describing experiences that influenced confidence to do statistics, but given that their brief exposure to statistics in relation to mathematics, this is not surprising. Students did identify the service-learning experience as a positive influence on confidence to do statistics and comparatively, felt more confident about doing statistics than mathematics.

To conclude, the purpose of this study was not to quantify changes in attitudes and beliefs, but to qualify them. In this sense, students' attitudes and beliefs regarding statistics overall reflected more positive perspectives than those regarding mathematics. The greatest influences on statistics-related attitudes and beliefs were the real-life setting of the problems and examples in class, the relative ease of the material, and as the next section reviews, the service-learning experience.

Summary of the Role of Service-Learning

Service-learning allowed students to experience performance mastery through a classroom project that modeled real world statistics according to their own definition of

"doing statistics." Without prompting, students identified the service-learning project as having played a positive role in developing their confidence to do statistics. Students cited reasons that included the impact the project had for real people in need and being required to produce a product that others in the community were depending on. However, given that students' only experience with statistics was the one in this course, it is difficult to determine whether service-learning actually caused an increase in confidence to do statistics. It is reasonable to assume that the potential is there and to conclude that students' positively perceived the service-learning experience.

Students were intrigued by the project but at first, they were intimidated by its demands. Students worried that coordinating schedules among teammates would be difficult because of time restraints posed by multiple after school commitments and other course requirements. However, as students got further along in the project, they were surprised by their own abilities to coordinate their schedules, work as a team, and manage the project. Students communicated well with each other and shared responsibilities fairly.

Students found the context of this particular project to be interesting, enjoyable, and eye opening. It required that they learn about the experiences of refugees, experiences that were difficult to imagine, but that helped them gain perspective on their own day-to-day struggles. In the process, students became more socially aware and felt compelled to get involved in making life better for refugees. Students enjoyed working with The Agency as a way to take action towards making this change and in the process, students became more socially responsible.

Implications

Teacher-research has long since been accepted as an informal way for teachers to gather information that can help them to improve their own teaching practices and student learning (Cochran-Smith, 2005). In other words, teacher-research can generate knowledge applicable to the teacher and the teacher's immediate community. In some cases, teacher-research reaches a larger population of educators, for example, through journals aimed at sharing instructional strategies and classroom accounts with other teachers. While this kind of knowledge is undoubtedly valuable, Lytle and Cochran-Smith (1992) believe that teacher-research has the potential to play a much more influential role in the larger research arena. In other words, it is generally accepted that teacher-research can generate *local* knowledge, but it can also generate *public* knowledge (Lytle & Cochran-Smith, 1992). I direct the following discussion toward the implications of this study for the broader community of researchers and educators.

The findings of this study have implications that apply to four primary audiences. There are implications for mathematics and statistics education researchers, for service-learning researchers, for mathematics and statistics educators, and for curriculum developers. Some implications apply to more than one audience.

First, the study shed light on the relationship between attitudes and beliefs regarding mathematics and attitudes and beliefs regarding statistics, indicating that they are not one in the same. Previous research in statistics education has tended to overlook this relationship, thus creating the challenge of building an accurate and robust theoretical knowledge base. For researchers, this finding implies that future studies should take into account the potentially confounding relationship between attitudes and beliefs regarding

mathematics and statistics. Additionally, in order to build a cohesive body of literature pertaining to mathematical and statistical affect, researchers must continue working to develop conceptual clarity in both fields. Applying a framework like Op t' Eynde, De Corte, and Verschaffel's (2002), will assist in achieving such clarity and will make synthesis of the body of literature less problematic.

Secondly, the study indicated that students' beliefs regarding mathematics are generally less positive than students' beliefs regarding statistics. This finding has implications in two ways. First, for mathematics educators and curriculum developers, this finding implies that there is still work to be done towards improving students' attitudes and beliefs regarding mathematics. These students believed that mathematics is useful, but not in the forms they have thus far experienced in the classroom. This suggests that students are not yet experiencing classroom mathematics that corresponds to real world uses of mathematics. By real world uses, students mean things like money management and on the job applications. Curriculum developers should consider including more consumer mathematics in the mainstream curriculum. Mathematics educators might consider finding out the career interests of students and try to incorporate relevant activities. For example, students could interview a professional in a career of interest to determine the type of mathematics applicable to that career.

For statistics educators, knowing that students may view statistics more positively than mathematics presents an opportunity to capitalize on students' openness to statistics. These students believed that statistics has greater personal relevance than other kinds of mathematics because it can help them to better understand people and the world around them. Teachers can use knowledge like this to booster positive attitudes and beliefs

among students by designing instructional activities that are anchored in real world scenarios, preferably those that enhance students' understanding of issues that are important to them. This leads to the last implication.

The perception of the students in this study was that service-learning positively influenced their confidence to do statistics. Students found joy and pride in serving their community and developed confidence in their own abilities to use statistics when they were able to see the positive impact of their work on other peoples' lives. This finding contributes to the body of service-learning literature by suggesting a positive influence of service-learning on self-efficacy among an understudied group, high school students, in an understudied field, statistics education. Because students are interested in better understanding and serving the world around them, service-learning can be a powerful vehicle to facilitate deeper understanding of statistics concepts while catering to students' interests.

To summarize, this study has local implications as well as implications for a more public audience of researchers, educators, and curriculum developers. The study contributes to the knowledge base of mathematics and statistics education by identifying parallels and divergences between students' attitudes and beliefs regarding mathematics and those regarding statistics. This knowledge has implications for researchers of statistical affect. It emphasizes the importance of research that takes into account the potentially confounding relationship between attitudes and beliefs regarding mathematics and statistics. It also exemplifies the need for research that clearly applies a conceptual framework of the affective domain so that synthesis of the body of literature is less difficult.

This finding also has implications for statistics and mathematics educators and curriculum developers. High school statistics educators can take advantage of opportunities to boost attitudes and beliefs regarding statistics before students enter college by structuring classroom activities anchored in real life scenarios such as service-learning. Educators and curriculum developers can establish personal relevance of mathematics by designing classroom activities that allow students to practice applying mathematics in real scenarios. According to these students, real world mathematics means applications in terms of money management and career applications.

Finally, the study has implications for service-learning research. It contributes to the body of service-learning literature by confirming the potential for service-learning to positively influence students' confidence to do statistics. The significance of this finding is less about the positive influence of service-learning on confidence, since this outcome has already been established in other service-learning literature (see Eyler, Giles, & Grey, 1999; Giles & Eyler, 1998). Rather, this finding is significant because it applies to high school students and in a statistics course.

Limitations

There are several limitations of the study that should be noted. The first limitation concerns the methodology applied to the study. By assuming the role of teacher-researcher, I gained insights into the research that an outside researcher may not have, however, it is possible that because I was also consumed with all of the other responsibilities that come with being a teacher, I may have missed details that could influence the research. One of Huberman's (1996) critiques of teacher-research pertains to the difficulty in managing the responsibilities of both teacher and researcher: "Since

the approach calls for a dual role, teacher and researcher, there are also qualms about the time spent on inquiry eating into the requisite time for learning" (p. 127). On the other hand, time spent for learning can eat into time spent on inquiry. Teacher-research requires a delicate balance between both roles and maintaining this balance is challenging. If I tipped the scale at any point during the research, it was in favor of learning. My first priority was my role as teacher. However, to the best of my abilities, great efforts were taken to employ techniques of rigor.

The second limitation of the study concerns the transferability of the findings with regard to the service-learning aspect. Implementing service-learning takes time and effort well beyond what would normally be involved in planning a typical course. In addition, it takes the support of administration, parents, and community members. The success of the project hinges in large part on the quality of the partnership with the community agency. Developing quality partnerships also takes time, resources, and support. Within the confines of public school, it requires special dedication and circumstances to implement service-learning, so it is understandable that the audience that would be most open to this model is affiliated with private institutions. However, I question any system that limits the possibilities for teachers and students to become active in making positive change within their community. I also encourage all teachers to push the limits of the resources available to them and give service-learning a try, even if the model used is not as extensive as the one in this study.

Given the abundance of resources available to me as well as the flexibility I was allowed, my teaching environment was ideal for a service-learning model. But even under the best circumstances, implementing service-learning in a *high school* statistics

course has its own special set of challenges. The current literature does not address these challenges because its focus is either at the college level or in a discipline other than mathematics or statistics. In a high school course there are some logistical considerations that are not as problematic at the college level. Scheduling out-of-class service time and transportation restrictions for non-drivers are just two issues that could be more difficult to overcome with younger students.

Also, younger students have less experience managing projects that require as much flexibility as the one in this study. Thus, they require more constant supervision and detailed feedback than college students might need. It requires a great deal of creativity and planning to identify community projects that are developmentally appropriate specifically for high school statistics students. It is easier to conceive of service-learning projects for elementary or even middle school students that involve simplistic mathematics or data analysis, yet that are educationally rewarding. It's also easy to conceive of statistical consulting-type service-learning projects that require maturity and statistical sophistication. These would be more appropriate for college students and adults. However, for high school students that fall in between these groups, the task of identifying an appropriate service-learning project is not as straight forward. Of course, this does not mean it is not possible, it just requires commitment and ingenuity. I was fortunate to have the assistance of the service-learning director at my school, though without a network of peer teachers doing similar work, navigating through the challenges of the course can be an isolating experience.

The last limitation of the study concerns its scope. Research indicates that attitudes and beliefs tend to stabilize in high school and are slow to change thereafter

(Presmeg, 2002; Wilkins & Ma, 2003). These students had only one classroom experience with statistics and all of the prior school years of experience with classroom mathematics. Therefore, their belief system as is pertains to statistics was not as matured as it was with regard to mathematics. This study spanned over one semester and then many of the participants graduated and left for college. Additional changes in attitudes and beliefs may not have manifested until after the course was over and participants accumulated other experiences. In fact, I saw Kelly at a school event at the end of her first semester of college. She approached me at told met that she had just taken a course that required some statistics. She said that she realized that what she learned in my class was more valuable than what she could understand at the time. I didn't have a chance to discuss this in detail with her then, but I hope to follow up with her and the other students in the study in future research.

Recommendations for Future Study

Four suggestions for future research are noted below. The first follows directly from the limitation last mentioned. Future studies should examine the long-term influence of service-learning on high school students' attitudes and beliefs through longitudinal study. Having had a positive experience doing statistics in high school, do students approach mathematics or statistics in college with more confidence or with greater success? What new insights or perceptions do they gain about the influence of service-learning on their attitudes and beliefs after accumulating more life experiences? As previously noted, I hope to conduct follow up research with the participants in this study to investigate these and other questions.

The second recommendation for future research also pertains to service-learning. Having established anticipated personal and social outcomes associated with service-learning-based statistics, future studies should examine learning and achievement outcomes. Indeed, number one on the service-learning agenda's list of the top ten unanswered questions is "How can service-learning enhance subject-matter learning?" (Giles & Eyler, 1998, p. 65). Arguably, academic outcomes associated with service-learning are more difficult to measure (Kraft & Krug, 1994), which explains the shortage of these kinds of studies and the priority of them on the service-learning research agenda.

One of the challenges of service-learning research stems from the variability among service-learning projects. While there are well-established guidelines and principles for quality service-learning (Porter-Honnet & Poulson, 1989), projects come in all different designs and formats. Even in this study, the model I chose was only one of many possibilities. Therefore, my third recommendation for future research is an investigation of the influence of various models of service-learning-based statistics on high school students' attitudes, beliefs, and achievement. In my case, while I believe the overall outcome of the course and the service-learning project was positive, I do not claim that it was perfect. In retrospect, the circular model that I chose to integrate service-learning (see Appendix F) may not have been the most effective model and I intend to investigate other models. At least initially, students found the demands of the service-learning project to be worrisome. During the member-checking session, I asked students if they had suggestions for making the service-learning project more manageable. Students suggested covering statistics topics in advance, before beginning the service-learning project, so that they could just focus on developing a solid understanding of

topics. Then, in the latter part of the course, they suggested shifting to the service-learning project. This way, they wouldn't have to learn new topics and manage the service-learning project at the same time. Additional research is needed to establish criteria for determining the most effective model of service-learning taking into account factors such as students' age and ability levels, the subject matter, availability of resources, the nature of the service, and the degree of flexibility in the curriculum.

Finally, this study examined the relationship between mathematics- and statistics-related attitudes and beliefs according to only a subset of the mathematics-related belief system. Given the findings that indicate apparent convergences and divergences between global beliefs about mathematics and domain-specific beliefs about statistics, additional research should consider other categories of beliefs. Applying Op t' Eynde, De Corte, and Verschaffel's (2002) framework of students' mathematics-related beliefs system, such categories might include beliefs about the teaching of mathematics and statistics, self beliefs that include control, task-value, and goal-orientation beliefs, and beliefs about the social context of mathematics and statistics.

Closing Statement

I close with some final statements about the study, its outcomes, and directions for future work. This study indicates a promising outlook toward improving students' attitudes and beliefs regarding statistics. Service-learning has the potential to build students' confidence about doing statistics in such a way that reinforces what students believe to be a useful application of statistics. However, there is much work to be done in order to determine what model of service-learning is most effective for high school

statistics students. In addition, more research is needed to determine the influence of service-learning on statistics achievement.

The study offers new insights into the relationship between attitudes and beliefs regarding mathematics and attitudes and beliefs regarding statistics. These insights provide new perspectives for future research into the affective domain of statistics. The disparity between beliefs about mathematics and beliefs about statistics indicates that perhaps different pedagogical approaches are required to create and maintain positive dispositions toward each subject. Furthermore, students' generally negative attitudes and beliefs regarding mathematics indicate that there is more work to be done here as well.

Before efforts can be taken to effectively *change* attitudes and beliefs, we must first understand *what* attitudes and beliefs students hold and *why*. This study offers a slice of insight into the 'what' and 'why' of this statement. I argue that in order to truly change students' attitudes and beliefs about mathematics and statistics for the better, educators, researchers, policy makers, and curriculum developers must start listening to the students. They want to grow up to be independent and self-sufficient adults. They want to pursue a wide variety of careers and effectively direct their energy toward what is needed to achieve these goals. They want to learn to work in the real world and need practice doing it, not in terms of word problems that have little relevance and meaning in a realistic sense. They want to better understand and change the world around them. These are conscientious and practical needs and wants. Whether through service-learning or some other instructional model, these needs and wants should be at the heart of mathematics and statistics education.

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APPENDIXES

APPENDIX A

INQUIRY AUDIT LETTER OF ATTESTATION NUMBER 1

Charge: To determine confirmability, dependability, and review credibility measures.

Purpose: To examine the process and product of inquiry of the study titled *High School Students' Attitudes and Beliefs in a Service-Learning-Based Statistics Course*, conducted by investigator, Jennifer Leong. Metaphorically, the inquiry audit is like that of a fiscal audit (Lincoln and Guba, 1985). Specifically, the task of the inquiry auditor is to determine the extent of trustworthiness of inquiry based on audit trail records provided by the investigator.

Process: The algorithm referenced in conducting this audit is that of Edward Halpern from his 1983 dissertation. Items provided by the investigator were as follows: raw data, data reduction and analysis notes, data reconstruction and synthesis notes, process notes, and reflexive journal entries. The questions used to determine confirmability, dependability, and to review credibility measures were as follows:

I. Confirmability

a) Has an appropriate analytic technique been selected?
b) Has the analytic technique been applied properly?
c) Do variables accurately describe concepts?
d) Do category labels accurately describe concepts?
e) Do categories represent an exhaustive use of the data? Support saturation?
f) Do examples clearly explain categories?
g) Do examples fairly represent data?
h) Are there illogical or unsubstantiated interpretations of data?
i) Are there alternative inferences possible?
j) Are the unexplained phenomena or unused data?
k) Is there an imposition of inquirer's own terminology in the data?
l) Are there sufficient efforts to ensure confirmability?

II. Dependability

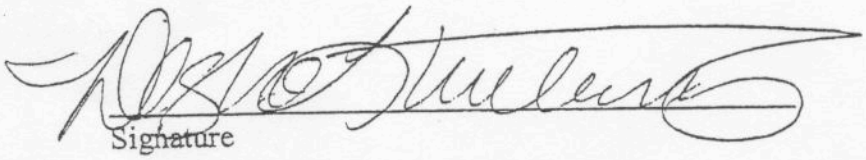
a) Is there evidence of purposive or theoretical sampling?
b) Is there support for purposive/theoretical decisions?
c) Are there unexplored areas in the field notes?

d) Was the focus influenced by a sponsoring agency?
e) Are there shifts in feelings of empathy?
f) Is there unused, conflicting evidence?
g) Is there an overemphasis of personal notes in the analysis?
h) Is there sufficient support to substantiate findings?
i) Is there an unbalanced reliance on one method?
j) Are there sufficient efforts to ensure dependability?

III. Review Credibility

a) Is there evidence of triangulation?
b) Is there evidence of member checking?
c) Are the raw data isomorphic with phenomena under investigation?

Overall Attestation: I have reviewed the data collected for this study and I found the data relevant to the research questions. The process of data analysis follows the criteria set forth by Lincoln and Guba. The interpretations of the data appear to be in alignment with the data collected.



Signature

9/18/06
Date

Georgia State University
Professional Affiliation

Auditor Vita:

Desha Williams

Education

2002 - Present	Doctor of Philosophy - Teaching and Learning - Mathematics Education Georgia State University
2000-2001	Master of Education - Mathematics Education Georgia State University
1990-1995	Bachelor of Science - Mathematics, Magna Sum Laude Morris Brown College

Professional Experience

2003 – Present *Clinical Instructor,* Georgia State University

1999-2003 *Mathematics Teacher*, Rockdale County High School

Presentations

Williams, D. & Gardner, K. (2005). Contextual Teaching in a Mathematics Classroom. Georgia Council of Teachers of Mathematics Conference. Eatonton, GA. October 20 – 22.

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APPENDIX B

INQUIRY AUDIT LETTER OF ATTESTATION NUMBER 2

Charge: To determine confirmability, dependability, and review credibility measures.

Purpose: To examine the process and product of inquiry of the study titled *High School Students' Attitudes and Beliefs in a Service-Learning-Based Statistics Course*, conducted by investigator, Jennifer Leong. Metaphorically, the inquiry audit is like that of a fiscal audit (Lincoln and Guba, 1985). Specifically, the task of the inquiry auditor is to determine the extent of trustworthiness of inquiry based on audit trail records provided by the investigator.

Process: The algorithm referenced in conducting this audit is that of Edward Halpern from his 1983 dissertation. Items provided by the investigator were as follows: raw data, data reduction and analysis notes, data reconstruction and synthesis notes, process notes, and reflexive journal entries. The questions used to determine confirmability, dependability, and to review credibility measures were as follows:

I. Confirmability

a) Has an appropriate analytic technique been selected?
b) Has the analytic technique been applied properly?
c) Do variables accurately describe concepts?
d) Do category labels accurately describe concepts?
e) Do categories represent an exhaustive use of the data? Support saturation?
f) Do examples clearly explain categories?
g) Do examples fairly represent data?
h) Are there illogical or unsubstantiated interpretations of data?
i) Are there alternative inferences possible?
j) Are the unexplained phenomena or unused data?
k) Is there an imposition of inquirer's own terminology in the data?
l) Are there sufficient efforts to ensure confirmability?

II. Dependability

a) Is there evidence of purposive or theoretical sampling?
b) Is there support for purposive/theoretical decisions?
c) Are there unexplored areas in the field notes?
d) Was the focus influenced by a sponsoring agency?
e) Are there shifts in feelings of empathy?

f) Is there unused, conflicting evidence?
g) Is there an overemphasis of personal notes in the analysis?
h) Is there sufficient support to substantiate findings?
i) Is there an unbalanced reliance on one method?
j) Are there sufficient efforts to ensure dependability?

III. Review Credibility

a) Is there evidence of triangulation?
b) Is there evidence of member checking?
c) Are the raw data isomorphic with phenomena under investigation?

Overall Attestation: I have reviewed the process and product for this inquiry. Based on the data collected and the reported results, I feel that trustworthiness of the inquiry has been established.

Kimberly Gardner — 9/16/2006

Signature — Date

City Schools of Decatur, Georgia State University
Professional Affiliation

Auditor Vita:

Kimberly Gardner

Education

Doctoral Candidate	*Teaching and Learning: Mathematics Education* Georgia State University, Atlanta, GA
1998	M.Ed. in *Secondary Mathematics Education* Georgia State University, Atlanta, GA
1991	B.A. in *Mathematics* Mercer University, Macon, GA

Professional Experience

1999 - present	City Schools of Decatur, Mathematics Teacher, Department Chair Decatur High School, Decatur, GA

1992 - 1999	Fulton County Board of Education, Mathematics Teacher Westlake High School, Atlanta, GA

Presentations

Williams, D. & Gardner, K. (2005). Contextual Teaching in a Mathematics Classroom. Georgia Council of Teachers of Mathematics Conference. Eatonton, GA. October 20 – 22.

References

Halpern, E. S. (1983). *Auditing naturalistic inquiries: The development and application of a model*. Unpublished doctoral dissertation, Indiana University.

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Beverly Hills, CA: Sage Publications, Inc.

APPENDIX C

PARENTAL CONSENT FORM

Georgia State University
Informed Consent Form

Title: Attitudes and Beliefs in Service-Learning-Based Statistics
Principal Investigator: Jennifer Leong

I. Introduction

Service learning is a teaching method that uses a community project. While working with a local community agency, students use what they learn in class to do a real study that helps the agency in some way.

There are three main purposes of the study. The first is to determine how attitudes and beliefs about mathematics relate to those about statistics. The second is to determine the role of service learning in shaping attitudes and beliefs about statistics. The third is to measure changes in confidence to complete statistical tasks over the course of a term.

You are being asked to allow your child to voluntarily participate in a research study. The length of this research is 13 weeks, one term. The study will begin during the second week of February 2005. The study will include up to 11 other participants.

II. Procedures

You decision to allow your child to participate is not about completing class assignments. It is about allowing me to use your child's data from certain class assignments for research purposes. Participation in the study will not require that your child complete any extra work beyond regular class work. Regular course assignments that will also be included in the study are two surveys, two writing assignments, and weekly journal assignments. Each survey will be given at the beginning and at the end of the term. Each survey will take about 15 minutes to complete.

Only the journaling assignments will be graded. They will be graded based on completion only. I will just be checking to see that your child has turned in each journal on time. Only after I assign a grade to each journal will I read it. Then I will provide your child with extensive feedback. Writing assignments will not be read until after course grades are given. Therefore, your child's grade in the class will NOT be affected by the study.

Please return this form sealed in the enclosed enveloped. I will not open this envelope until after the course is over and grades are submitted. Therefore, there is no risk that your child will be treated any differently because of his or her decision to participate in the study or your decision to allow him or her to participate.

All surveys and work will be kept private under lock and key in a file drawer. I will have the only key to this drawer.

III. Risks

There are no expected risks to your child for participating in this study.

IV. Benefits

All students in the course will benefit from an opportunity to learn in a rich and engaging environment. Indirectly, you and your child will have the pleasure of helping to develop a course that will benefit other students.

V. Voluntary Participation and Withdrawal

Participation in research is voluntary. You have the right to refuse to allow your child to be in this study or to withdraw your child from the study at any time. Should your child decide to be in the study, he or she also has the right to drop out at any time. He or she may also skip questions on any assignment related to the study. Whatever is decided, your child will not lose any benefits to which he or she is otherwise entitled.

VI. Confidentiality

Your child's records will be kept private to the extent allowed by law. A fake name will be used rather than actual names on study records. Your child's name and other facts that might point to them will not appear when I present this study or publish its results.

VII. Contacts

Please call Jennifer Leong at 404-377-3491 ext. 274 or Dr. Christine Thomas at 404-651-0200 if you have any questions or concerns about this study at. You may also contact the Institutional Review Board (IRB), which oversees the protection of human research participants. Susan Vogtner in the office of research compliance can be reached at 404-463-0674.

VIII. Copy of Consent Form

Participants and parents or guardians will be provided with a copy of this form to keep.

Please check the box below indicating whether or not you wish to allow your child's data for use in this research.

☐ I DO wish to allow my child's data for use in this research. Please sign below.

☐ I DO NOT wish to allow my child's data for use in this research.

Parent/Guardian/Legally Authorized Representative	Date
Jennifer Leong - Teacher/Researcher	Date

APPENDIX D

PARTICIPANT ASSENT FORM

Georgia State University
Informed Assent Form

Title: Attitudes and Beliefs in Service-Learning-Based Statistics
Principal Investigator: Jennifer Leong

You are being asked to volunteer for a research study. Results from the research will provide valuable information for designing a service-learning statistics course that will offer a rich and engaging experience for high school students. Service learning is a teaching approach that uses a community project. Students directly apply what they are learning in class through the project.

The length of this study is 13 weeks, one term. The study will begin during the first week of February 2005. The study will include up to 11 other participants.

You decision to participate is not about completing class assignments. It is about allowing me use of data from certain class assignments for research purposes. Participation in the study will not require that you complete any extra work beyond regular class work. Regular course assignments that will also be included in the study are two surveys, two writing assignments, and weekly journal assignments. Each survey will be given at the beginning and at the end of the term. Each survey will take about 15 minutes to complete.

Only the journaling assignments will be graded. They will be graded based on completion only. I will just be checking to see that you have turned in each journal on time. Only after I assigned a grade to each journal will I read it. Then I will give you provide you with feedback. Writing assignments will not be read until after course grades are given. Therefore, your grade in the class will NOT be affected by the study.

Please return one copy of this form sealed in the envelope you have been given. I will not open this envelope until after the course is over and grades are turned in. This is so there is no risk that you will be treated any differently because of your decision to participate in the study or your parent or guardian's decision to allow you to participate.

All surveys and work will be kept private under lock and key in a file drawer. I will have the only key to this drawer.

There are no expected risks or discomforts from being in this study. There are no expected direct benefits from participating in this study, though you will have the satisfaction of helping to develop a course that will benefit other students.

Participation in the research is voluntary. You have the right to refuse to be in this study. Should you decide to be in the study, you have the right to drop out at any time. You may also skip questions on any assignments related to the study. Whatever is decided, you will not lose any benefits to which you are otherwise entitled.

Your records will be kept private to the extent allowed by law. A fake name will be used rather than your actual name on study records. Your name and other facts that might point to you will not appear when I present this study or publish its results.

You will be provided with a copy of this form to keep.

Please check the box below indicating whether or not you wish to allow your data to be used in this research.

☐ I DO wish to allow my data for use in this research. Please sign below.

☐ I DO NOT wish to allow my data for use in this research.

Participant	Date
Jennifer Leong - Teacher/Researcher	*Date*

APPENDIX E

PROJECT DESCRIPTION FOR PROSPECTIVE PARTNERS

Goal

To enhance students' understand of introductory statistics concepts through meaningful service to the community in the form of a statistical consulting project with a local community agency. Project outcomes are intended to inform some aspect related to the mission of the agency in a way that helps the agency to better achieve its own goals.

The Project

Project Structure

The project should provide opportunities to engage all 15 students for the duration of 11 weeks. The teacher will work with agency representatives to determine the question(s) that will drive the project. The project may address a broader question with several secondary questions within *one* department or it may address several smaller scale questions across *multiple* departments.

Sample Driving Questions

What is the best way to recruit and retain volunteers?
What factors influence soup kitchen attendance? With what level of certainty can attendance be predicted based on weather patterns?
What is the most effective way to package and deliver food to the homebound, critically ill?

Sources of Data

Data sources will depend on the driving questions. Data may come from surveys, interviews, records, or other public sources. The project may require that students design data collection instruments and gather the data directly or students may analyze data previously collected by the agency.

Project Components

- Introduction/Orientation
- 1 - 2 Service Opportunities
- 2 - 4 Interim Reports
- Final Report/Presentation

Situating the Project Within the Course

The project will be incorporated throughout the course so that project tasks coincide with topics covered in class (Figure 1).

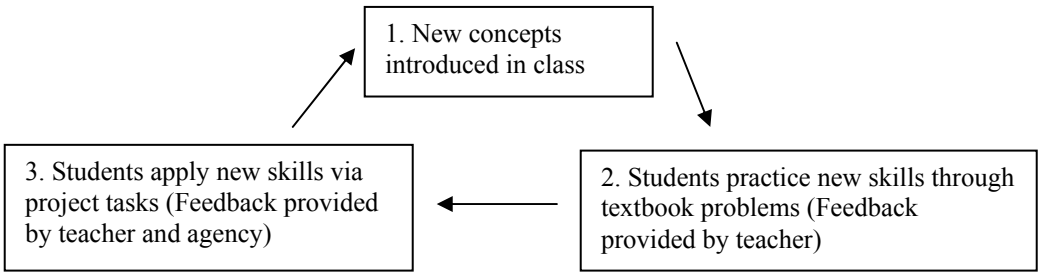

Figure 1. Cyclical process for integration of project with course content

Roles

- *Students* will design and implement a statistical analysis in accordance with project guidelines provided by the teacher.
- *Agency representative(s)* will collaborate with the teacher in advance to determine the research design of the project including service components, provide relevant data or access to relevant data, and provide feedback when needed on other project components.
- *Teacher* will facilitate and monitor students' progress in carrying out the project and communicate project status to agency representative(s).

Timeline

October - January*:* Planning Phase - teacher and agency representative(s) collaborate to develop project blueprint
February 7 - April 29: Project Implementation
May 4: Final Presentation

APPENDIX F

OUTLINE OF SERVICE-LEARNING PROJECT

Driving Question

How can human and financial resources best be utilized to collect and distribute household items to local refugees?

Methods (Programs)

1) Lighten the Load
2) Yard Sale Collections
3) Other (TBD by students)

Factors

1) Time
2) Cost
3) Quality of Donations
4) Quantity of Donations

Decisions

Continue, modify, or discontinue programs

Outcomes

Agency

1) System for monitoring/recording donation status
2) Extractable sound bites for brochures, grants, donation requests
3) Partnership in education - Advocacy through youth
4) Potential volunteer/intern base

Student

1)Learning
   a. Design and implement program evaluation (project management)
   b. Descriptive statistics

2) Personal/Social
   a. Heightened awareness of refugee related issues
   b. Social Responsibility
   c. Teamwork/collaboration

Timeline (February 7 - May 4)

Week 1 - Orientation/Refugee Research (throughout course)/Assignment to Project
Week 2 - 3 Project Planning (Report 1, Evaluation Plan Due), Site visit to agency offices
Weeks 4 - 9 Project Implementation - Data Collection and Analysis (Report 2, Status Report Due), Service opportunity #1
Week 10 - Prepare presentation, Service opportunity #2
Week 11 - Prepare final presentation
May 4th - Final Presentation (Report 3, Final Report Due)

APPENDIX G

EVALUATION PLAN

Based on : Reeves, T.C. (n.d). *Evaluation plan template*. Retrieved January 3, 2005,

from http://it.coe.uga.edu/%7Etreeves/edit8350/EPT.html

Using the template below, your task is to develop an evaluation plan for your team's program. One unique aspect of this plan template is that it encourages you to consider decisions that must be made and should be influenced by the evaluation data you collect. The strategy seems simple, but is very challenging in actuality.

Remember that your job is to evaluate the effectiveness of your program from a cost-benefit perspective. Your final evaluation should provide evidence that supports your recommendations to continue, discontinue, or to modify your program.

You should provide sufficient detail for each of the twelve sections, but be concise. The plan should be double spaced, using 12-point font, and free of grammatical or spelling errors.

EVALUATION PLAN COMPONENTS

A. Introduction: This section introduces the major sections of the plan as well as the primary people involved in writing the plan.

B. Background: This section describes any information which is needed to provide the reader with an understanding of the background of the project that is being evaluated.

> Briefly discuss refugee needs and THE AGENCY. Then describe the project that you are evaluating.

C. Purposes: This section thoroughly describes the purposes of the evaluation. A single plan can address a variety of purposes, but all must be delineated clearly. Evaluation is always a political process and all parties must accept the purposes for the evaluation to be successful.

Clarify goals and objectives of the evaluation.

D. Audiences: This section specifies all the *primary and secondary* audiences or consumers of the evaluation. In general, it is recommended to open the evaluation up to as many people or agencies as the client will allow.

E. Decisions: This section is probably the most difficult, but it should be included if the evaluation is to have meaningful impact on decision-making. Trying to anticipate the decisions which can be influenced by an evaluation takes creativity and trust. Many developers do not wish to anticipate negative outcomes for their efforts, but these too must be considered.

Our decisions are whether to continue, modify, or discontinue programs.

F. Questions: A key element of a sound evaluation plan is careful specification of the questions to be addressed by the evaluation design and data collection methods. The clearer and more detailed these questions are, the more likely that you will be able to provide reliable and valid answers to them.

You may have primary and secondary questions. The questions should CLEARLY address the goals and objectives of the project.

G. Methods: This section describes the evaluation designs and procedures. There are scores of designs and hundreds of procedures which can be used. The keys to success are matching these options to the purposes and questions of your client and keeping within the budget and time line of the study.

Determine available resources. The evaluation questions should drive the methods you select. In other words, be sure the methods (and instruments) will provide you will the data you need to answer your questions.

H. Sample: This section specifies exactly which students, trainers, and other personnel will participate in the evaluation. If necessary, a rationale for sample sizes should also be included.

The sample sometimes refers to a sample of people or artifacts. In our case, we are looking at a sample of donations from each project over a short time period. Refer to dates provided in Report 1 guideline.

I. Instrumentation: This section describes all the evaluation instruments and tools to be used in the evaluation. Actual instruments should be included in appendices for review and approval.

You must design instruments that you will use to record pertinent information about donated items as well as associated costs. These instruments should be clear and concise. They should include directions on how to use them so that someone who knows nothing about the project could use it.

J. Limitations: This section spells out any limitations to the interpretation and generalizability of the evaluation. It should also describe potential threats to the reliability and validity of the evaluation design and instrumentation.

Terms

Generalizability: The degree to which the results of a study or an evaluation extend to the larger population.

Reliability: The extent to which a study or evaluation yields the same results when repeated under the same conditions.

Validity: The degree to which a study or and an instrument measures what it claims to measure.

K. Logistics: This section spells out who will be responsible for the various implementation, analysis, and reporting aspects of the evaluation.

This should be a team effort. How will you ensure that work is distributed equitably and that quality work is produced?

L. Time Line: This section presents the schedule for implementation, analysis, and reporting of the evaluation.

Project Implementation Phase (Data Collection and Analysis): March 28 - April 13th

- 2 Pickups/Collections should be scheduled, one during the week of March 14th, and one during the week of March 28th
- Analysis should begin after the first pickup and should continue after the second pickup, concluding by April 13th.
- Report 2 (Status Report) Due March 22

Conclusions/Final Report Preparation Phase: April 14 - May 3

- Presentation of Final Report May 4th

*These dates are tentative and may require slight modification

APPENDIX H

PROGRAM STATUS REPORT

Based on : Reeves, T.C. (n.d. b). *Evaluation Status Report*. Retrieved January 5, 2005,

from http://itech1.coe.uga.edu/~treeves/edit8350/ESR.html

The "Project Status Report" is a very simple tool with a very important purpose. Statisticians or researchers that are conducting a project or program evaluation use these reports to keep the client and the project team informed and up to date. Typically, the project manager should prepare project status reports at regular intervals, usually once a week. For this class assignment, you should work together with your teammates to prepare it. Be sure to read the entire report over after it is compiled and check for clarity, cohesiveness, and spelling/grammar errors.

Each member should sign off on the report once it is complete.

Instructions:

1. Your "Project Status Report" should contain the following elements:

- A title referring to the project.
- A date and identification of the persons preparing the report.
- A list of accomplishments since the first report.
- A list of pending items yet to be resolved.
- A list of any concerns and recommended actions to resolve them.
- Any other remarks that might be made to inform, reward, or motivate team members.

APPENDIX I

FINAL REPORT

There are six sections of your final report. A description of what is expected to be included in each of these sections is listed below. Each section should be headed and easy to find. You should be able to use your evaluation plan to greatly supplement your writing of this report, although the results and conclusions sections rely on work you've done since the evaluation plan was written. Therefore, these sections will require original writing. This should be done as a team effort. Later, you will be scoring each other on your success as a team as well as individual contributions.

I expect a high quality report that is free of grammar and spelling errors. It should be thorough, accurate, well written and easy to read. Someone who knows nothing of this class or this project should be able to understand it. It should be a document that could be handed to a real client (and it will be given to THE AGENCY). A scoring rubric for this report follows at the end of this document.

The final report should be dated and titled. It should contain each of the following sections:

Introduction (See evaluation plan)

This section must list the other sections in the document and introduce the key players in the evaluation (your teammates and myself).

Background (See evaluation plan)

This section must provide relevant background information pertaining to The Agency as well as a detailed description of the project itself and how it was implemented.

Purpose and Research Questions (See evaluation plan)

This section should clearly state the purpose of the evaluation and the research questions (and subquestions) that follow as a result.

Results

This section should contain an opening paragraph that explains the charts and tables that

follow. There should be two bar charts - one that shows a breakdown of donations by category and one that shows a breakdown of donations by quality ranking. The mean and the standard deviation of the quality rankings should be included as well as an explanation of the quality ranking scale. In addition, this section must contain a table that summarizes the costs associated with your project. Each chart and table must be clearly labeled and titled.

Conclusions

This section is where you pull it all together. Based on your analysis, you should address each of the research questions, referring to the data you've provided. You should discuss any limitations of your results in this section as well (see evaluation plan). This is not the place to discuss your personal opinion of the project, though it is appropriate to discuss parts of the project's implementation that were particularly challenging from a logistical (not personal) viewpoint or particularly rewarding.

Appendix

In this section, you must include your raw donation data in table form. This is the data that you have recorded in excel. In addition, you must include a detailed description and itemization of associated costs in table form.

APPENDIX J

SURVEY OF MATHEMATICAL AND STATISTICAL AFFECT (SMSA)

Directions:	For each of the following, please fill in the blanks according to you how you currently feel about the statement pertaining to MATHEMATICS. Attach additional sheets as necessary.

1. I believe **mathematics** is mostly … (useful, interesting, boring, scary, etc.) because…
2. I believe **mathematics** is about … (What topics? What skills?)
3. I *like* **mathematics** that involves …(What topics? What skills? Write "not at all" if you so feel so) because…
4. I *dislike* **mathematics** that involves … (What topics? What skills? Write "not at all" if you so feel so) because…
5. I expect that **mathematics** may be later useful for … (Write "not at all" if you so feel so)
6. When I envision myself doing **mathematics**, I see myself …(Doing what?)
7. When I envision a mathematician doing **mathematics**, I see them … (Doing what?)
8. In **math**, I'm really confident that I can do …(What topics? What skill? Write "not at all" if you so feel so) but I'm not as confident that I can do …(What topics? What skill? Write "not at all" if you so feel so)

Directions:	For each of the following, please fill in the blanks according to you how you currently feel about the statement pertaining to STATISTICS. Attach additional sheets as necessary.

9. I believe **statistics** is mostly … (useful, interesting, boring, scary, etc.) because…
10. I believe **statistics** is about … (What topics? What skills?)
11. I will *like* **statistics** that involves …(What topics? What skills? Write "not at all" if you so feel so) because…
12. I will *dislike* **statistics** that involves …(What topics? What skills? Write "not at all" if you so feel so) because…
13. The math that is needed in **statistics** includes… (What topics? What skills?)
14. I expect that **statistics** may be later useful for … (Write "not al all" if you so feel)
15. When I envision a statistician doing **statistics**, I see them… (Doing what?)
16. When I envision myself doing **statistics**, I see myself …(Doing what?)

17. In **statistics**, I'm really confident that I can *learn* to do… (What topics? What skill? Write "not at all" if you so feel so), but I'm not as confident that I can *learn* to do …(What topics? What skill? Write "not at all" if you so feel so)

APPENDIX K

COURSE ACTIVITIES VERSUS RESEARCH ACTIVITIES BY WEEK

Week	Course Activities	Research Activities
1	Introduction, Background Readings on Refugee Issues	Distribute and collect sealed consent/assent forms, Administer SMSA (Pre), Narrative 1
2	Refugee agency representative visits class, students determine third program, viewing of *Hotel Rwanda*, distribute and discuss Report 1	Open-code SMSA and Narrative 1, Journal entry 1
3	Work on Report 1 Topics covered: sampling, bias, variability, confidence statements, margin of error	Journal entry 2
4	After school visit to The Agency and visit with refugee family, work on Report 1 Topics covered: sampling errors, survey design,	Journal entry 3
5	Exam 1, finalize Report 1	
6	Project data collection Topics covered: experimental design, statistical significance, quantitative versus qualitative research, measuring, validity, reliability	Journal entry 4
7	Project data collection Topics covered: five number summary, box plots, mean and standard deviation	Journal entry 5
8	Spreadsheet lab, submit Report 2, project data analysis Topics covered: creating and interpreting graphs and charts	Journal entry 6
9	Exam 2, project data analysis, distribute Report 3 guidelines Topics covered: normal distribution, scatterplots, correlation, and regression	
10	Finalize project data analysis, work on Report 3, Topics covered: permutations and combinations	Journal entry 7

Week	Course Activities	Research Activities
11	Work on Report 3 Topics covered: probability of dependent and independent events	
12	Exam 3, finalize Report 3	SMSA (Post), Narrative 2
13	Present Report 3 to Agency representatives and class, submit and distribute course grades	Open Code SMSA and Narrative 2, unseal consent/assent forms (after grade submission), member checking session

APPENDIX L

CODEBOOK

Variable	Codes
General Beliefs about Mathematics (GBM) 100's	160 Nature of Mathematics 161 Level of Difficulty 162 Utilization 163 Interest
Attitudes Toward Mathematics (ATM) 200's	260 Comprehension (like) 261 Time (dislike) 262 Usage (like) 263 Usage (dislike) 264 Topic/Task (like) 265 Topic/Task (dislike) 267 Comprehension (dislike)
Beliefs about Doing Mathematics (BDM) 300's	360 Problems 361 Discovery 362 Formulas 363 Complexity 364 Usage
Confidence Doing Mathematics (CDM) 400's	460 Previous Experience 461 Performance Mastery 462 Teacher 463 Pacing 464 Social Comparisons 465 Family 468 Task 469 Peers 470 Vicarious Experience 471 Verbal/Social Persuasion 472 Physiological States
General Beliefs about Statistics (GBS) 500's	560 People 561 Collecting Data 562 Analyzing Data

	563 Interpreting Data
	564 Usage
	565 Interest
	566 Math Needed
	567 Percentages
	568 Level of Difficulty
Attitudes Toward Statistics (ATS)	660 Usage
600's	661 Time (dislike)
	662 People
	663 Comprehension (dislike)
	664 Interest
	665 Topic/Task (dislike)
	666 Comprehension (like)
	667 Topic/Task (like)
Beliefs about Doing Statistics (BDS)	760 People
700's	762 Collecting Data
	763 Analyzing Data
	764 Interpret/Reporting Data
Confidence Doing Statistics (CDS)	860 Task
800's	861 Performance Mastery
	862 Service-Learning
	864 Social Comparison
	865 Change
	867 Vicarious Experience
	868 Verbal/Social Persuasion
	869 Physiological States
	870 Family
	871 Peers
	872 Teacher
	873 Transitions
Service-Learning (SL)	960 Teamwork
900's	961 Dependability
	962 Logistics
	963 Confidence
	964 Disconnection to Course
	965 Connection to Course
	966 Social Awareness
	967 Social Responsibility
	968 Attitude