

CULTIVATING MATHEMATICAL AFFECTIONS: DEVELOPING A  
PRODUCTIVE DISPOSITION THROUGH ENGAGEMENT IN  
SERVICE-LEARNING

by

Joshua B. Wilkerson, Th.M.

A dissertation submitted to the Graduate Council of  
Texas State University in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy  
with a Major in Mathematics Education  
May 2017

Committee Members:

Sharon Strickland, Chair

Gilbert Cuevas

Samuel Obara

Dave Klanderman

**COPYRIGHT**

by

Joshua B. Wilkerson

2017

## **FAIR USE AND AUTHOR'S PERMISSION STATEMENT**

### **Fair Use**

This work is protected by the Copyright Laws of the United States (Public Law 94-553, section 107). Consistent with fair use as defined in the Copyright Laws, brief quotations from this material are allowed with proper acknowledgement. Use of this material for financial gain without the author's express written permission is not allowed.

### **Duplication Permission**

As the copyright holder of this work I, Joshua B. Wilkerson, authorize duplication of this work, in whole or in part, for educational or scholarly purposes only.

## **DEDICATION**

This dissertation is dedicated to my amazing wife, Laura Wilkerson. She has been the perfect partner in this endeavor of pursuing graduate degrees while starting a family. I could not have completed any of this work without her support and encouragement. Every day I thank God for the blessing of being her husband. Her selfless, Christ-like love is the most tangible grace that I have experienced in my life. This work in its entirety is dedicated to her. I love you Laura.

## **ACKNOWLEDGEMENTS**

I would like to thank my committee members for all of their feedback and advice on refining and improving my research.

I would also like to thank Regents School of Austin for their encouragement and support as I pursued my degree while still teaching full-time. I am thankful that Regents has allowed me the opportunity to implement service-learning projects in my classes and to gather data for this research.

I would like to thank countless friends and family, especially my parents, Joe and Terri Wilkerson, for their encouragement and support through my studies.

Finally, I would like to thank all of the math teachers I had over the years. Thank you for challenging me to pursue my passion.

## TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS .....	v
LIST OF TABLES .....	xi
LIST OF FIGURES .....	xii
LIST OF ABBREVIATIONS .....	xiii
ABSTRACT .....	xiv
CHAPTER	
I. INTRODUCTION .....	1
Introduction.....	1
Statement of Problem.....	2
Purpose of the Study and Research Questions.....	6
Significance of the Study .....	9
Definitions.....	10
II. LITERATURE REVIEW.....	12
An Overview of Research on Affect in Math Education .....	12
Instilling Values .....	14
Virtues Practiced by Students .....	19
A New way of Understanding Affect in Education .....	21

The Aims and Outcomes of Service-Learning.....	23
Examples of Service-Learning in Math and Statistics Courses .....	27
Theoretical Framework .....	36
Conceptual Framework .....	38
III. METHODOLOGY .....	40
Introduction.....	40
Design .....	42
Setting .....	47
Sample.....	50
Instruments.....	51
Surveys.....	51
Observation Protocol .....	52
Reflection Journal .....	54
Interviews.....	54
Data Collection .....	56
Data Analysis .....	58
Limitations .....	59
Pilot Study.....	61
Data Collection .....	62
Data Analysis .....	64
Implications.....	69

IV. RESULTS: INTRODUCTION AND QUANTITATIVE DATA .....	71
Introduction.....	71
Quantitative Data .....	74
Fennema-Sherman Math Attitude Scale .....	74
Observations .....	83
Community-Based Learning Survey.....	89
V. RESULTS: QUALITATIVE CASES .....	92
Introduction.....	92
Tabitha .....	94
Ava.....	102
John.....	110
Charlotte.....	117
Mason.....	126
Summary .....	137
VI. RESULTS: PRODUCTIVE DISPOSITION .....	138
Productive Disposition.....	138
Sensible .....	139
Useful .....	148
Worthwhile .....	169
Summary of Productive Disposition.....	195
Additional Themes.....	196



Relational (Empathy) .....	196
Grit .....	204
Mindset .....	209
<b>VII. RESULTS: SUMMARY OF FINDINGS IN THE CONTEXT OF RESEARCH QUESTIONS .....</b>	<b>219</b>
Research Question 1: To what extent does service-learning impact the cultivation of mathematical affections among students? .....	220
Research Question 2: What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project? .....	232
Research Question 3: To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education? .....	238
<b>VIII. DISCUSSION .....</b>	<b>247</b>
Introduction .....	247
Major Findings of the Study .....	247
Research Question 1: To what extent does service-learning impact the cultivation of mathematical affections among students? .....	247
Research Question 2: What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project? .....	248
Research Question 3: To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education? .....	250
Relation to Similar Studies .....	252

Clinical Relevance of Findings .....	254
Suggestions for Further Research .....	255
Limitations of the Study.....	256
Conclusion .....	258
APPENDIX SECTION .....	261
REFERENCES .....	285

## LIST OF TABLES

<b>Table</b>	<b>Page</b>
1. Krathwohl's Affective Domain of Learning and Corresponding Research Organization .....	13
2. Summary Characteristics of Ten Representative Students in Study .....	44
3. Summary Characteristics of Five Students in Final Case Study .....	50
4. Summary of Research Questions and Methods of Measurement .....	56
5. Summary of Research Questions and Methods of Measurement .....	72
6. Highest and Lowest Single Question Averages on FSMAS Survey .....	79
7. Statistical Results of CBSL Survey .....	90
8. Definition of Key Terms Related to Productive Disposition .....	139
9. Summary of Research Questions and Methods of Measurement .....	219
10. Krathwohl's Affective Domain of Learning and Corresponding Research Organization .....	221

## LIST OF FIGURES

Figure	Page
1. Theoretical and Conceptual Framework .....	39
2. Summary of Time Frame for Student Project.....	47
3. Average FSMAS Scores at Start of the Project .....	74
4. Average FSMAS Scores at End of the Project .....	75
5. Paired Differences in FSMAS Scores (After – Before).....	75
6. Starting FSMAS Score v. Change in FSMAS Score .....	77
7. Summary of Observed Inferred Affect .....	85
8. End-of-Year Average v. End-of-Year FSMAS Score .....	93
9. End-of-Year Average v. Change in FSMAS Score .....	94
10. Summary of CBSL Survey Responses Related to Sensibleness.....	140
11. Summary of CBSL Survey Responses Related to Usefulness.....	149
12. Summary of CBSL Survey Responses Related to Worthwhileness .....	170
13. Summary of CBSL Survey Responses Related to Productive Disposition .....	232
14. Summary of CBSL Survey Responses Related to Time Allocation.....	239
15. Summary of CBSL Survey Responses Related to SL Implementation .....	242

## LIST OF ABBREVIATIONS

Abbreviation	Description
CBSL	Community-Based Service-Learning
FSMAS	Fennema-Sherman Math Attitude Scale
PO	Partner Organization
SL	Service-Learning

## **ABSTRACT**

This research explores the impact of service-learning on the affective outcomes of secondary mathematics curricula. This was a qualitative case study of high school students who recently completed a service-learning project in their mathematics course. Data was gathered from student interviews, reflection journals, and field observations. The framework for the analysis follows the definition of "productive disposition" offered by the National Research Council (2001). The major themes that emerge from the data indicate that through service-learning students see math as sensible, useful, and worthwhile. This supports the potential of service-learning as a pedagogical tool that can be utilized to develop a productive disposition in students; addressing at a practical level how the affective objectives of national policy documents can be achieved.

## CHAPTER I: INTRODUCTION

### **Introduction**

“When am I ever going to use this?” is a statement that is often on the ears of every mathematics teacher. Please notice that I referred to this as a *statement* and not as a *question*. It has been my experience as an educator that the true nature of “When am I ever going to use this?” is typically not as a legitimate inquiry as to the appropriate timeframe in which the student will eventually apply the material at hand in a “real-life” scenario, rather, the phrase more often arises as a statement. It is a statement of frustration. It is the culmination of confusion and stress and typically serves as an exclamation by the student of their withdrawal from the mental activity at hand.<sup>1</sup> The real issue being raised by students is not one of application, but rather one of *values*. I have found that the best response to such a statement/question is to first translate it into what I believe the student truly meant to express, turning “When am I ever going to use this?” into “Why should I *value* this?” It is my belief that modern society (and the current educational system) has conditioned students (and people in general) to value things (including knowledge) for their practicality. So as the students begin to formulate the true question of “Why should I value this?” they phrase it in a way that expects a response in terms of how math will get them ahead in life, earn them more money, and in general fix all their problems. While the utility of mathematical concepts is certainly important, we as mathematics educators need to utilize the mathematics classroom to address the more

---

<sup>1</sup> Certainly the question “When am I ever going to use this?” can be a legitimate question of curiosity on the part of student. It has simply been my experience (and I have found the experience of my colleagues as well) that the students asking the question legitimately would fall in the minority. Generally students asking this question seem very unsatisfied with a time-frame response of future applications, hinting that there is something deeper motivating their question/statement.

fundamental issue of fostering a proper sense of values. Learning has little meaning unless it produces a sustained and substantial influence not only on the way people think, but also on how they feel and act. I believe that we as math educators need to do a better job of what I have termed “cultivating mathematical affections,” that is developing a consistent appreciation for the discipline of mathematics apart from cognitive achievement on formal assessments.

### **Statement of Problem**

Affective language permeates national published standards on the teaching of mathematics as an ideal we should strive to inculcate into students but there is little discussion on *how* to go about doing this. The NCTM Standards for Teaching Mathematics (1991) states that “Being mathematically literate includes having an appreciation of the value and beauty of mathematics as well as being able and inclined to appraise and use quantitative information.” Mathematical literacy involves a proper valuation of the discipline of mathematics. *Adding it Up: Helping Children Learn Mathematics*, a report published by the National Research Council (2001) argues that mathematical proficiency has five strands, one of which is termed “productive disposition.” Productive disposition is defined as “the habitual inclination to see mathematics as sensible, useful, and worthwhile” (p. 116). To be mathematically proficient (not just literate, but proficient) the valuation of mathematics must lead to a habit of seeing mathematics as worthwhile.

In both these documents there are two clear examples of affective objectives for students of mathematics with no supporting information on how to reach those objectives. Why might this be the case? In a special issue of *Educational Studies in*



*Mathematics* devoted entirely to affect in mathematics education, Rosetta Zan notes that “affect has generally been seen as ‘other’ than mathematical thinking, as just not part of it” (Zan 2006, p. 113). However, one could argue that education is inherently affective; it is inherently value-laden. It is not a question of “*Are* you teaching values?” but rather “*Which* values are you teaching?” Even the statement “We should not be focusing on values in the classroom” is itself a value-based statement. Perhaps the stance taken by the math education research community by in large is that if educators focus on cognitions, on raising standards and developing innovative teaching practices designed to increase content knowledge, then the affections of students will follow. In other words, national policy documents on the aims of math education seem to indicate that if students *know* math first then they will value and appreciate it.

However, as it stands the current methods of teaching are producing untold numbers of students who see mathematics more about natural ability rather than effort, who are willing to accept poor performance in mathematics, who often openly proclaim their ignorance of math without embarrassment, and who treat their lack of accomplishment in mathematics as permanent state over which they have little control (McLeod, 1992). In a foundational article on affective learning in mathematics in the *Handbook of Research on Mathematics Teaching and Learning*, Douglas McLeod notes how teachers will often talk about their mathematics classes in terms of their students’ enthusiasm or hostility toward mathematics more than simply reporting on their cognitive achievements. Similarly, students are just as likely to discuss affective as cognitive responses, comments about liking (or hating) mathematics are as common as reports of instructional activities (McLeod, 1992, p. 575). These informal observations support the

view that affect plays a significant role in mathematics learning and instruction. McLeod might as well have been writing today. He goes on to cite efforts to reform mathematics curriculum and those reform efforts' emphasis on the role of affect. The specific documents he cites are the National Council of the Teachers of Mathematics (NCTM) Standards for School Mathematics (1989) and the National Research Council's report on math education titled *Everybody Counts* (1989). As noted above, the problem addressed in this study is very much along the lines of McLeod though it will be structured in a different way, and it begins by focusing on statements made in the NCTM's Standards for Teaching Mathematics (1991 & 2000) and the National Research Council's report *Adding it Up: Helping Children Learn Mathematics* (2001). McLeod's work will be discussed in more detail below. However, due to the strikingly similar starting points between his and my arguments, the unchanging language of national published standards, and the similar situations of finding research on affect on the periphery, it can be argued that McLeod's work has yielded few results and is in need of an adjustment.

McLeod's basic argument is to re-conceptualize affective learning into three main areas: beliefs, attitudes, and emotions. Each of these categories can be broken down according to the direction of focus (outward, inward, toward the teaching of mathematics, toward the learning of mathematics, etc.) and the strength of feeling. The flaw of McLeod's approach is that only the category of attitude fits properly within the affective domain of learning as developed by Krathwohl (1964). According to Krathwohl, the affective domain of learning is really about demonstrated behavior, attitude, and characteristics of the learner. Beliefs are more cognitive (and McLeod admits as much) and emotions are typically intense and quite fleeting making them difficult to gauge in

any research sense. McLeod also admits this point, offering the example of the joy a student may feel over having an ‘aha’ moment of discovery and insight. To be fair, the point of McLeod’s approach was to find a way to tie in affective components more closely to cognitive components of research. However, what is really needed in mathematics education is an actual framework for developing an understanding of affective learning in and of itself, primary to cognitive development, which can then be tied back to cognitive approaches, rather than essentially redefining affective learning to make it mesh better with our understanding of cognition. To use McLeod’s second category, it is the attitudes that need adjusting.

As mentioned above, the affective domain of learning is really about demonstrated behavior, attitude, and characteristics of the learner (Krathwohl, 1964) rather than subjective emotions the learner experiences. If mathematics educators and researchers can come to understand this definition of affective learning then it will be easier to see how a more systematic approach to affective teaching might be developed and affective assessments may be considered legitimate evaluators of student growth. What this study is ultimately meant to address is the habits of our students, how they are instilled, how they are encouraged (or discouraged), and how they are evaluated.

In summary, the problem statement addressed by this study is that there is a gap in the literature for discussing *how* to enrich the affective experiences of students in the math classroom while research overwhelmingly addresses how to enrich the cognitive experience of students. If a productive disposition is to truly be developed then mathematics teachers need more tangible tools at their disposal for cultivating this disposition in students.

## **Purpose of the Study and Research Questions**

The purpose of this case study will be to analyze the role of service-learning in the cultivation of mathematical affections for students in a suburban high school mathematics classroom as they participate in a service-learning project. At this stage in the research, the cultivation of mathematical affections will be generally defined as developing a consistent appreciation for the discipline of mathematics apart from cognitive achievement on formal assessments. Service-learning will be examined as a potential pedagogical tool that can be utilized to develop a habitual inclination to see mathematics as worthwhile.

Let me take a moment to define more clearly what is meant by “mathematical affections.” This phrase is in homage to Jonathan Edwards’ *Treatise Concerning Religious Affections*. Edwards’ goal was to discern the true nature of religion and in so doing dissuade his congregation from merely participating in a religious culture, a mimicked outward expression, and motivate them to long for true conversion, an inward reality of authentic character. The purpose of this study is to engage educators in discerning the true nature of mathematical pedagogy, and how educators approach the teaching and learning of mathematics: does it simply mimic the modern culture of utility by requiring outward demonstrations of knowledge retention and application, or does it aim deeper at analyzing true inward character formation? For Edwards, affections were not synonymous with emotions as they tend to be in today’s mathematics education research as noted by Zan (2006). Edwards understood affections as aesthetics – a way of orienting your life via a mechanism that determines what is beautiful and worthwhile. Affections are character producing and habit forming. It can be argued that Edwards’

definition of affections (orientation of life, determining worth) is what actually appears in the policy documents that have been cited above. Consider once more that being mathematically literate involves having an appreciation of the value and beauty of mathematics (cf Veatch, 2001), and being mathematically proficient involves a habitual inclination to see mathematics as worthwhile. Foundational documents in the area of mathematics education plainly portray mathematics as beautiful, of value, and affecting the habits of the learner to see mathematics as worthwhile. However, none of these documents develops *how* teachers are to go about accomplishing this task.

Service-learning potentially offers one tangible practice than can be instituted in the mathematics classroom as a means of inculcating the mathematical values into students which national policy documents aim for. The question at hand is does service-learning offer a vehicle for the discussion of *how* to go about instilling the values that the math education desires to see in its students? Service-learning in its most effective and well-developed sense involves a multilayered reflection process that can substantially increase its educational value in a broad sense: service-learning reflection asks the learner to become more aware of what he/she brings to the learning process: values, assumptions, biases – many of which are unexamined and potentially problematic (Zlotowski 2005, p. ix).

As noted by Zlotowski, the process of reflection in service-learning allows the students to examine what values they bring to the learning process (many of which have been never before been examined). It would seem that the pedagogical practice of placing students in these service-based contexts that are rich with opportunities for discussion and reflection, all within the overarching goals of a mathematics course, move closer to

achieving the goal of instilling an appreciation for mathematics within the hearts of students.

The proposed study will seek to answer the following research questions:

1. To what extent does service-learning impact the cultivation of mathematical affections among students?
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?

The research reviewed below will show that if human beings are primarily affective learners then much more research needs to be done and reexamined in regards to the emphasis on the affective domain of learning in the math classroom. There is work being done in philosophy and cognitive science that indeed argues for the primacy of the affections above the cognitions. This research will propose three stages of analyzing affective learning in the mathematics classroom, each of which is born out of statements on national standards on teaching and assessing mathematics: instilling values, practicing virtues, and assessing affections. This model helps provide some cohesion to research that has been done on the affections and situate it in a context that helps explain both the positive aspects and the shortcomings of the study. The model that is being proposed is potentially effective at addressing *how* to go about the cultivation of mathematical affections. Research indicates that affections are formed through the day-to-day routines

and subconscious habits of the individual (Smith, 2009). Also, introducing guided reflective activities has been demonstrated to increase student appreciation of a given subject (Hulleman, 2010). Therefore the benefits of integrating more reflective activities into the daily habits of the math classroom will be argued. In particular, service-learning will be examined as a vehicle for introducing such periods of reflection.

### **Significance of Study**

When students ask “When am I ever going to use this?” most mathematics teachers will answer this surface question rather than the underlying values-based question. Answers will range from “You’ll need this to be able to handle money properly as an adult” to “You’ll need this to understand what you’ll learn next year” and the basic “You’ll need this to pass the test next week.” If a teacher is really clever then they’ll revamp their curriculum to include multiple application-based problems in various scenarios in order to address the question before it is even asked. All of these approaches ignore the underlying values. In fact, these answers actually reinforce the students’ perception that value only stems from application and utility. I believe that part of the reason the question is answered in these application-focused ways is because application is something educators are much more familiar with in the context of teaching as compared with values. Application is the third level of Bloom’s Taxonomy, in the cognitive domain (Bloom, 1956; Anderson, 2000). Valuing is the third level of Krathwohl’s Taxonomy, in the affective domain (Krathwohl, 1964). It is my argument that mathematics teachers in general are under-trained in the affective domain and therefore do not realize that the underlying value-based question of students is just as reasonable to address as the surface level application-based question. Now, application is

certainly useful in the teaching process and it should not be ignored. This study is not advocating the promotion of the affective domain over and above the cognitive. The goal is to simply bring the affective up to the same level as the cognitive; to utilize both domains in conjunction with each other. As a result of this study perhaps teachers of mathematics will come to realize that affective learning is not simply based on subjective emotions (though emotion may play a small part in affective learning), rather it's about demonstrated behavior, attitude, and characteristics of the learner (Krathwohl, 1964) – all of which are deeply linked to success in the mathematics classroom.

### **Definitions**

1. Mathematical Affections – at this stage in the research, the cultivation of mathematical affections will be generally defined as developing a consistent appreciation<sup>2</sup> for the discipline of mathematics apart from cognitive achievement on formal assessments. This definition is in keeping with the “productive disposition” strand of mathematical proficiency defined in *Adding it Up: Helping Children Learn Mathematics* (2001): the habitual inclination to see mathematics as worthwhile (p. 116).
2. Service-Learning – at a basic level, service-learning can be defined as a set of activities that have two characteristics: 1) they enhance either the delivery or the impact of the curricular material, usually, but not always, within the context of a specific course, and 2) they take place within a service framework where

---

<sup>2</sup> As measured by the Fennema-Sherman Math Attitudes Scale (FSMAS) (Fennema & Sherman, 1976; Mulhern & Rae, 1998) as described in the methodology section below.



additional experience with civic engagement or social contribution will be obtained (Hadlock, 2005a, p. 2).

## **CHAPTER II: LITERATURE REVIEW**

This literature review will give a brief overview of research being done on affect in mathematics education and how affect has largely played a secondary role to cognition. A new way of viewing affect as primary to cognition will be put forward based on work in contemporary philosophy and psychology. By “primary” I mean a research approach that understands affective development and formation as the main outcome of schooling, rather than cognitive development. Then the question “how do we instill values in students in the classroom?” in light of this new view on affect will be addressed. Finally literature on service-learning will be examined and service-learning will be seen as a feasible pedagogical practice that is line with an understanding of the primacy of affect, in keeping with the literature on how to instill values in students, and results in the stated affective aims of national policy documents on mathematics education.

### **An Overview of Research on Affect in Math Education**

The purpose of this portion of this research is to orient the reader to the current state of research on affect in mathematics teaching and learning since the time of McLeod’s article in 1992. It can be argued that perhaps the affective domain of learning has often been misunderstood or misrepresented in the mathematics classroom. Research seems to approach affective learning as subjective and emotional and therefore it does not fit well with the objective mindset that is often associated with mathematics teaching and learning; nor does it fit well with mathematics education research which often requires a high degree of objectivity. In a special issue of *Educational Studies in Mathematics* devoted entirely to affect in mathematics education, Rosetta Zan states:

Affect has been a focus of increasing interest in mathematics education research. However, affect has generally been seen as ‘other’ than mathematical thinking, as just not part of it. Indeed, throughout modern history, reasoning has normally seemed to require the suppression, or the control of, emotion (Zan, 2006, p. 113).

The research that exists on affect can be organized into two different categories: research that examines instilling values in students and research that examines virtue practiced by the students. The research that is reviewed below will be organized according to these two points of emphasis. Table 1 below explains how Krathwohl’s categories for the affective domain of learning correspond to the organization of the argument of this paper and the research reviewed.

Table 1: Krathwohl’s Affective Domain of Learning and Corresponding Research Organization

		Krathwohl’s Affective Domain	Summary of domain category	Associated Verbs for Student Learning Objectives	This paper groups research that focuses on:
Virtues Practiced by Students	Behaviors from simple to complex	Characterizing	individual has a value system that has controlled his or her behavior for a sufficiently long time for him or her to develop a characteristic “life-style” – thus the behavior is pervasive, consistent, and predictable	Revise, require, rate, avoid, resist, manage, resolve	allowing values to inform practices
		Organizing	bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system	Discuss, theorize, formulate, balance, prioritize	
Values Instilled in Students	Behaviors from simple to complex	Valuing	the worth or value a student attaches to a particular object, phenomenon, or behavior	Measure proficiency, subsidize, support, debate	developing an attitude toward a particular subject, in this case mathematics
		Responding	active participation on the part of the student	Comply, follow, commend, volunteer, acclaim, engage in	
		Receiving	student's willingness to attend to particular phenomena of stimuli	Differentiate, accept, listen for, respond to	

### *Instilling Values*

The reference of “instilling values in students” is a broad label that can be applied to research that focuses on Krathwohl’s categories of receiving (refers to the student's willingness to attend to particular phenomena of stimuli), responding (refers to active participation on the part of the student), and valuing (concerned with the worth or value a student attaches to a particular object, phenomenon, or behavior). ‘Values’ is essentially referring to developing an attitude toward a particular subject, in this case mathematics. The NCTM Standards for Teaching Mathematics (1991) states that “Being mathematically literate includes having an appreciation of the value and beauty of mathematics as well as being able and inclined to appraise and use quantitative information.” Mathematical literacy, therefore, involves a proper valuation of the discipline of mathematics.

Much of the work being done under this sub-discipline of affect tends to be motivated primarily by cognitive needs. Consider, for example, that the emphasis on affective issues in the U.S. reform movement in mathematics education is related to the importance that the reform movement attaches to higher-order thinking (McLeod 1992, p.575). If students are going to be active learners of mathematics who willingly attack non-routine problems, their affective responses to mathematics are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low-level computation skills.

Building on the work of McLeod (and even using the same quote provided in the previous section of this paper), Maaz (2009) explains the historical perspective of research on affective issues in mathematics. The first case of such detailed research

stemmed from research on gender which led to an interest in attitudes toward mathematics (Fennema and Sherman, 1976). However Maaz notes that a more interesting direction in affect research has involved studies of mathematical problem solving (McLeod, 1989). Reform movements in mathematics education often place ‘problem-solving’ as a primary objective for students to learn. As such, research on curricula and pedagogies that involve a high degree of problem solving activities have not only reported on the cognitive skills of students’ problem solving but also report on changes in or observations of students’ affective responses to these curricula and pedagogies. For example, McLeod’s observations of students carrying out various problem solving tasks revealed that their reaction during the solution process could not be understood as a purely cognitive process. Problem-based learning leads to demonstrating a greater knowledge in solving more difficult math problems (cf Carpenter, et al’s 1989 Cognitively Guided Instruction study) and this knowledge ties it to shaping opinions – problems are challenging but students still have a feeling of success (Cotic, 2009). Lebens (2011) notes the importance of affective factors in mathematical achievement and how it differs by achievement bands – children of average ability are less influenced by affective factors than children with mathematical difficulties. Botella (2012) analyzed and described the importance of the emotional factors (emotions, beliefs and attitudes) in mathematics education. The study showed that the emotional factors and the academic performance of students were correlated, accentuating the need to grant a more important role to the affective components in order to improve the quality of the mathematics. Ma (2006) noted that although broadly changes in cognitive factors had more comprehensive effects on participation in a mathematics classroom than changes in affective factors did,

changes specifically in attitude (a specific type of affective factor) toward mathematics had the single most important effect on participation. Gomez-Chacon (2000) discusses the importance of taking into account affective factors in academically failing students and the article's main focus is on developing interactions between affect and cognition so as to explain emotion in more detail. Prawat (1994) examined the affective experiences of fourth and fifth graders engaged in mathematics seatwork. Students' affect was found to be primarily negative and achievement related. Anger was the most prevalent affective response.

These above examples seem to indicate a trend that much of the research on developing values (values as it has been defined above broadly, which may include some researchers' work on beliefs or attitudes) in the mathematics classroom is largely driven by increased attention to higher-order cognitive thinking and its impact on the affections of students, rather than vice-versa. That is, researchers intending to explore the cognitive effects of curricula or pedagogy can end up also reporting on interesting affective observations and sometimes these secondary reports seem to be unexpected findings and thus are framed as consequences of the cognitive shifts in the learners. This ordering of the cognitive as primary and the affective as subservient to the cognitive tends to lead to some discrepancies in actually defining some of the affective terminology (i.e., beliefs actually being cognitive as opposed to affective). Despite the above body of work Sfard writes:

Finally, the self-sustained "essences" implied in reifying terms such as knowledge, beliefs, and attitudes constitute rather shaky ground for either empirical research or pedagogical practices – a factor of which neither research nor teachers seem fully aware (2008, p.56).

However, there does appear to be some work being done which studies the affections for the sake of the affections (as opposed to having cognitive concerns or bases). Taylor (2006) focused on mathematics anxiety as an attitude towards mathematics that affects students' perception of mathematics to the extent that mathematics is often seen as a barrier to success by many. This paper reports on the design, development and evaluation of an interactive multimedia resource designed to explicitly address students' beliefs and attitudes towards mathematics by having the students follow five fictional characters as they progress through the highs and lows of studying in a mathematics course. Further, it uses a number of multimedia alternatives (video, audio, animations, diary writing, interactive examples and self-assessment) to encourage students to feel part of a group, to reflect on their feelings and beliefs about mathematics, to expose students to authentic problem solving and generally build confidence through practice and self-assessment. Evaluation of the resource indicated that it encouraged students to value their own mathematical ability and helped to build confidence, while developing mathematical problem solving skills. Notice that cognitive problem-solving is still involved it just isn't given the primacy that the previously cited research had given it. The implementation of guided reflection is a key component of this study that we will return to when addressing service-learning.

There is some work being done on the basis of the discipline of psychology moving away from a strong tradition concerning the analysis of cognition and affectivity as dichotomous processes explaining human behaviors (Arujo, 2003). Such work aims to produce a new unit of analysis for the study of mathematical activity, integrating affectivity and cognition. While this is certainly a step in the right direction of integrating

the affective and cognitive, it doesn't go the extra step to suggest the primacy of the affective. This work is cited primarily as a reference to show that current trends in psychological analysis do indeed have implications for the teaching and learning of mathematics. A stronger statement in regards to the primacy of affective learning is made by Hannula (2006). In examining motivation in the math classroom, Hannula notes that in order to understand student behavior in classrooms we need to increase our understanding of what motivation is and how it is regulated. The first relevant issue that he discusses is the importance of the unconscious (or pre-conscious) in motivation. He also goes on to note that motivation cannot be directly observed, but rather it is only observable as it manifests itself in affect and cognition, for example as beliefs, values, and emotional reactions. Goldin (2002) extended the categories of affect by defining the category of values, ethics, and morals. Goldin (2006) also discusses a research-based theoretical framework characterizing affect as an internal representational system. Key ideas include the concepts of meta-affect and affective structures, and the constructs of mathematical intimacy and mathematical integrity. Goldin understands these as fundamental to powerful mathematical problem solving, and deserving of closer attention by educators. Hannula indicates a recognition of the pre-conscious (and hence pre-cognitive) aspect of motivation which can then influence students' affective actions. Goldin articulates an approach that sees affect as an internalized organization structure which is necessary for students to succeed in the cognitive task of mathematical problem solving. However, the drawback of each approach is the continued focused on improving student cognitions as the lone purpose of schooling.



### *Virtues Practiced by Students*

The reference of “virtues practiced by students” is a broad label that can be applied to research that focuses the last two stages of Krathwohl’s taxonomy of the affective domain of learning: organizing (concerned with bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system), and characterization by value or value set (individual has a value system that has controlled his or her behavior for a sufficiently long time for him or her to develop a characteristic “life-style” – thus the behavior is pervasive, consistent, and predictable). ‘Virtues’ simply refers to allowing values to inform practices. *Adding it Up: Helping Children Learn Mathematics*, a report published by the National Research Council (2001) argues that mathematical proficiency has five strands, one of which is termed “productive disposition.” Productive disposition is defined as “the habitual inclination to see mathematics as sensible, useful, and worthwhile.” To be mathematically proficient (not just literate, but proficient) the valuation of mathematics must lead to a habit of seeing mathematics as worthwhile. One fruitful point of research is offered by Malmivouri (2001 & 2006). Malmivouri is building off the work of McLeod, and McLeod even points to her work on his own personal website ([https://newscenter.sdsu.edu/education/crmse/douglas\\_mcleod.aspx](https://newscenter.sdsu.edu/education/crmse/douglas_mcleod.aspx) accessed May 8, 2015). So while there may be some underlying issues in McLeod’s approach as discussed above, here is an example of continuing work on the level of organization and characterization of student affections in mathematics classes. Malmivouri (2006) presents affect as an essential aspect of student’s self-reflection and self-regulation (which fits well with Krathwohl’s organization category in the affective domain). Students are

viewed as agents who constantly interpret and evaluate their experiences and regulate their behavior, in interaction with their mathematics learning environment. Not only are students organizing a value system in mathematics but they are evaluating it and allowing it to inform their behavior and habits. Research has also proposed moving beyond the individual student as the unit of analysis and into the classroom or social context as a whole. In Malmivouri (2001), a study was done that concentrated on the dynamic interplay of affect and cognition in school mathematics learning. The aim of the study was to produce a systematic analysis and rich theoretical description of the functioning of affect and cognition in socio-culturally and contextually-conditioned mathematics learning situations. Further theoretical deepening of these personal and unique situational dynamics resulted in a detailed analysis of meta-level processes, personal agency, self-regulatory reflections and actions as the core of students' personal mathematics learning or self-system processes and their affective self-experiences with mathematics. Moreover, these personal aspects or self-system processes were considered as the core of the dynamics of affect and cognition in mathematics learning processes in a social environment (the emphasis in the study being on the social environment as a means to analyze affections). Also, Haladyna (1983) argues that the unit of analysis is typically the individual student in examining attitudes towards mathematics but this ignores the social context of the classroom. He argues that analysis must be performed at the class level. This approach actually fits quite well with Krathwohl's development of typical verbs for the characterization phase of the affective domain, suggesting that a student "being rated highly by their peers" would be an optimal way to assess a student's characterization by a value or value set.

In summary, there is very little research available in regards to developing the organization and characterization levels of the affective domain in the mathematics classroom. Despite several potential reasons for the lack of work in this area there have been some promising approaches in incorporating the social aspects of the learning environment for discussing the value-based habits of learners. There is work being done on social/psychological interventions in education as a way to shape student values. Yeager et al (2013) states a position similar to that argued in this paper of suggesting that teachers should look beyond how they communicate academic content and try to understand and, where appropriate, change how students experience school (p. 62). In this same vein of research Hulleman (2010) shows that introducing a time of guided reflection significantly impacted students' valuation of the discipline. This guided reflection has been cited above and it plays a key role in the understanding the benefits of service-learning as will be discussed below.

### **A New Way of Understanding Affect in Education**

Having outlined the tendency of research on affect in math education to focus on cognitive outcomes, this section will begin with an analysis of work being done that suggests that human beings are primarily affective learners and then secondarily cognitive learners. All of the research cited above treats the affective domain of learning as needing to be interconnected with the cognitive domain but none of the research argues for the primacy of the affective domain. I would like to proceed with the following analysis: if human beings are primarily affective learners, how then do educators develop the affections?

From a philosophical perspective, much work has been done in the last century to support shifting the center of gravity of the human person from the cognitive to the non-cognitive – from the cerebral head to the affective region of the body (Heidegger, 1966; Brann, 2007). Now the reference of the “affective region of the body” is a significant one. Often the affective dimension of the human person is associated with the heart and emotion (as discussed above). However, current philosophical work seems to support the notion that it is the actions/habits of the body that work to form and portray affections (Smith, 2009). This philosophical notion seems to be confirmed by contemporary work in cognitive science as well (Wilson, 2004; Bargh, 1999). It is bodily practices that train the body (including the brain) to develop habits or dispositions to respond automatically in certain situations and environments. Smith (2003) noted that the dominant paradigms of social sciences reflect human beings as rational machines and he calls for a more holistic understanding of humans as believing (affective) or what he terms “narratological” animals (creatures driven by story at an affective level rather than logic and rationality at a cognitive level). Taylor (2004) notes that what humans think about is just the tip of the iceberg and cognition cannot fully or adequately account for how or why humans make their way in the world. For Taylor, there is something beneath the cognitive, what he terms “the imaginary” – defined as the way ordinary people imagine their social surroundings which is not expressed in theoretical terms but is carried in images, stories, and legends. Here Taylor uses “imaginary” not in the romantic sense of invention, but rather in reference to a pre-cognitive framework or lens through which we view and interact with the world. While much of the above work in philosophy and cognitive science needs to be developed in more detail as it pertains to mathematics education, it

nonetheless establishes the groundwork that such academic work on the primacy of affections is out there and is in fact growing.

In summary, the research discussed above shows a need for more work to be done on developing values in students integrated with cognitive development. Though cognition and affection are certainly interrelated, more research needs to be done on the assumption of the affections as primary to the students' learning process.

### **The Aims and Outcomes of Service-Learning**

One of the major contributors to the discussion of service-learning in mathematics is Charles Hadlock edited the book *Mathematics in Service to the Community: concepts and models for service-learning in the mathematical sciences* (2005), the most significant resource available to date on the topic. Hadlock has also penned various other articles and given presentations on service-learning in mathematics as well. Any discussion of the literature on service-learning in mathematics needs to begin with a synopsis of his reports. In his introduction to *Mathematics in Service to the Community*, Hadlock defines service-learning in a way that takes it beyond simply having math students tutor at an underprivileged school (not to say this act of service is not beneficial – it can in fact be extremely useful in courses for future math educators). At a basic level, service-learning can be defined as a set of activities that have two characteristics: 1) they enhance either the delivery or the impact of the curricular material, usually, but not always, within the context of a specific course, and 2) they take place within a service framework where additional experience with civic engagement or social contribution will be obtained (Hadlock, 2005a, p. 2). Hadlock goes on to note that the enhancement of curricular impact can derive from different sources, such as exposure to new techniques and ideas,

motivation from seeing curricular material in action, higher student energy level due to bonding with a client organization and helping meet its needs, or more extensive discussion of course material due to the interactive nature of most service-learning projects. What is key for Hadlock is that a carefully managed reflection process is used to ensure that students derive the full educational potential from their experiences, and he references some resources developed by Campus Compact, a national coalition of colleges and universities committed to the public purposes of higher education. He states: “Some people may think that this reflection process refers to a kind of ‘touchy-feely’ exercise that might be quite foreign to the mathematics classroom....” Here the quote from Zan above seems very apt.

Affect has been a focus of increasing interest in mathematics education research. However, affect has generally been seen as ‘other’ than mathematical thinking, as just not part of it. Indeed, throughout modern history, reasoning has normally seemed to require the suppression, or the control of, emotion (Zan, 2006, p. 113).

But Hadlock continues: “...I prefer to think of it as the processing of a rather complex set of experiences to assure that students share and solidify their insights and thus obtain maximum lasting benefits. This has actually been one of the most important contributions of the service-learning initiative” (Hadlock, 2005a, p.2). Hadlock goes on to argue that the effectiveness in mathematics learning that service-learning allows stems largely from increases in student motivation – an area of research that falls into the category of affect, not cognition. So from Hadlock’s introductory piece in the foundational work on service-learning in mathematics a couple of key points can be gleaned: 1) Hadlock offers a robust definition of service-learning that allows educators to identify a given project example as being a service-learning activity or not, 2) the need for a reflection process can potentially explain why service-learning is not widely instituted in mathematics courses

given that affective processing is seen as something other than mathematical thinking, and 3) Hadlock presents an underlying argument that service-learning ties heavily into student motivation and thus relates more with the affective side of learning rather than the cognitive (though cognition is obviously still involved). Ultimately the motivation for service-learning in Hadlock's view is not only developing higher-order critical thinking in real-world contexts but also increasing the feeling of engagement on the part of the student (Hadlock, 2013), or what might be termed as student motivation. Hadlock then clearly emphasizes the ability of service-learning to impact the affective domain of learning while still also regarding highly the cognitive learning objectives of a given course.

In the past decade, two unpublished dissertations are noteworthy to mention in regards to service-learning in the context of mathematics. Roemer (2009) sought to determine if the teaching and learning of mathematics would be enhanced by service-learning, in the context of a community college course. Where this present study differs from Roemer is the focus on the affective impact of service-learning. Roemer notes that practicable connections do exist between service-learning and mathematics, however results regarding enhanced teaching and learning (cognitive gains) through service-learning are mixed. Roemer argues that the reason for mixed results is that motivation in mathematics and community service is impacted by general student motivation and the quality of the service experience. In other words, Roemer's work seems to suggest that there is more to be gleaned by examining service-learning through an affective lens. Another important result from Roemer is her conclusion that reflection is critical to learning.

The second dissertation of note is the work of Leong (2006). Leong 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. These participants reported greater confidence doing statistics and attributed this confidence, in part, to service-learning. Participants also experienced a heightened sense of social awareness and social responsibility through the service-learning project. What is most notable about Leong's work is that it is one of the few pieces of research on service-learning in high school mathematics and also the fact that Leong notes these results provide evidence that service-learning can be utilized to solidify positive attitudes and beliefs regarding statistics among high school students. Leong offers service-learning as a clear vehicle to impacting student affect in mathematics. Where this study will differ from Leong is that Leong analyzed service-learning through McLeod's (1992) framework of the affective domain, whereas this study will reconceptualize affect based on the work of Smith (2009) as discussed below.

Service-learning is a pedagogical tool that research seems to indicate can be utilized to address the issues raised above (Hadlock, 2005b). Service-learning offers one tangible practice that can be instituted in the mathematics classroom as a means of inculcating the mathematical values into students which national policy documents aim for. Service-learning offers a vehicle for the discussion of *how* to go about instilling the values that the math education community desires to see in its students. As noted by Zlotowski (2005) in the earlier quotation, the process of reflection in service-learning allows the students to examine what values they bring to the learning process (many of which have been never before been examined explicitly by the students). This study will



seek to show that by placing students in these service-based contexts that are rich with opportunities for discussion and reflection, all within the overarching goals of a mathematics course, is taking a step in the right direction to actually achieve the goal of instilling an appreciation for mathematics within the hearts of students.

### **Examples of Service-Learning in Math and Statistics Courses**

A number of studies have examined the benefits of engaging in service-learning in a mathematics or statistics classroom. While none of these studies have analyzed service-learning in mathematics through the same theoretical and conceptual lens that I describe below (with an emphasis on cultivating positive affective responses through changing routines and practices), these studies nonetheless contribute to a foundation of research upon which this study can build.

The vast majority of literature available on service-learning in math-specific contexts can be characterized as descriptions of successfully instituted projects. As we will see, there still remains much work to be done on the level of synthesizing these projects with an understanding of effective mathematics pedagogy and exploring *why* it is that service-learning tends to produce such positive learning outcomes in (or in some instances, why it fails to do so). The majority of literature on service-learning in mathematics also tends to be related to courses at a collegiate level. For the purposes of this section I have chosen to focus on research that, at some level, goes beyond a mere description of a service-learning project and offers some insight as to how the students were impacted at an affective level. I have also chosen to limit these examples to lower level mathematics and statistics courses at a collegiate level – courses where the students are not necessarily math majors but rather a mix of interests and ability levels. Results

from these courses would seem to be the most applicable to studying the impact of service-learning in a secondary school context.

Hydorn (2011) notes that effective service-learning depends on several factors and can be implemented according to a variety of models – seven, to be precise (according to Hydorn), with some overlap. The first category is referred to as pure service-learning which is defined as having an intellectual core of service to the community. In mathematics this would involve building an entire social justice mathematics program across courses/grades or something similar. More common is disciplined-based service-learning where a specific single course content forms the basis for reflection and analysis of service activities. Hydorn argues that in mathematics this would describe projects based around providing mathematics tutoring or teaching in some form or fashion. The third category is problem-based service-learning that presumes that students have specific disciplinary knowledge to draw on to understand a problem and develop a solution for a community client. This is the category of service-learning in which the examples in the following sections can be best classified. Other categories offered by Hydorn include: capstone courses (which is essentially problem-based service-learning in a larger context), service internships where a reflection component is added to a typical internship, undergraduate community-based action research, and co-curricular service-learning (such as a student organization that performs pro bono statistical consulting). The focus of this literature review will be on problem-based service-learning as that is where the vast majority of available examples in research can be classified. It is also the problem-based service-learning examples that tend to fit more easily with Hadlock's

definition of service-learning discussed above and this also most closely relates to the case study of this work.

To be sure, there are examples in the research literature of discipline-based service-learning. For example, students enrolled in a finite mathematics course at an urban campus were given the option to tutor inner-city-at-risk youth (Zang, 2005). The college students sought to inculcate in these at-risk youths an appreciation for the difference between merely having facility with symbol manipulation versus actually understanding why various rules apply to a given problem; in so doing, the tutors themselves learned the lesson as well. Moreover, their ideas of social responsibility were influenced by contact with the youths they tutored. I make note of this study because of Zang's emphasis on developing an appreciation of the material in the course which is one of the ultimate goals in instituting service-learning projects. However, the remaining examples discussed below will best be classified as instances of problem-based service-learning. With this in mind we can now examine sample projects completed in quantitative literacy and general education courses.

First we will examine service-learning in quantitative literacy type courses. The use of service-learning in these courses alone is important to note as it demonstrates that students need not be involved in higher level mathematics in order to successfully implement meaningful service-learning projects. This provides even more incentive for exploring the benefits of service-learning in lower levels of math education in the K-12 setting. Even in lower level quantitative literacy courses, under the right guidance and structure, students are able to analyze data from service agencies and generate both written and oral reports on their findings (Stanish, 2011). The implementation of service-

learning was credited with increasing student engagement in a course that tends to include students with negative views of mathematics. Taking this a step further, Ankney (2011) examined two general-education math courses that focused on social justice issues in housing finances, census data, and transportation. One class learned about injustices, while one class worked for justice while they learned the material – in essence Ankney is analyzing using math to *learn* justice versus using math to *do* justice. The results of this study show an increase (though not a statistically significant one) on course average for those in the experimental group (the *do* justice group) and a statistically significant increase in their performance on the final exam. Another interesting result of this study is that in response to a written survey, there was more disagreement (in terms of increased variation on Likert scale responses) from the control group (the *learn* justice group) in regards to the statement “I’m not sure about what to do when I see a mathematical problem,” whereas there was more agreement from the control group on the statement “I am quite good at mathematics.” This reveals the double-edged sword of service-learning in mathematics: it tends to increase student engagement and open their mind to think more creatively on a given problem, but at the same time it reveals how complicated real-world mathematical problems tend to be. Overall Ankney argues for increased achievement when students experience a real-life application of the material covered.

Now we turn our attention to service-learning in education courses. I have grouped these along with the quantitative literacy courses as by in large (though not always) the students present in these courses tended to have weaker mathematical backgrounds (for instance students might be majoring in elementary education and this is the one math course they were required to take), although there are certainly cases where

the mathematical abilities of students in education courses is indeed very great. For instance, college students with majors and minors in math and math education have helped to design and implement math events for elementary and middle school students (Klanderman, 2013). Formal and informal reflections on these service-related experiences have demonstrated the potential impact on future teaching and learning goals for the pre-service teachers. The impact of service-learning is evident even in classes where the level of mathematical knowledge of the participants is not great. Students majoring in elementary education have organized family math nights at local elementary schools (Myers, 2005). Future teachers realized the need for developing deep mathematics content knowledge, while reinforcing their desire to serve the community. Math carnivals also provided the teacher candidates with an opportunity to work with the K-12 students in small groups, thus alleviating some of the anxiety that may be present concerning pedagogical skills or the math content itself (Bonari, 2005). Another example of a special educational event is a mathematical scavenger hunt for elementary aged students (McDowell, 2005). Students can also do more than organize one special event; their involvement in service-learning can be more ongoing. University students in math classes for elementary education attended local K-12 schools to assist in tutoring activities, ultimately enhancing student learning (Dwyer, 2005). The community math teaching project (Morse, 2005) is a service-learning course in which undergraduates learn principles of pedagogy and gain a new understanding of geometry through teaching weekly labs to small groups of urban high school students.

Service-learning has proved very successful at the community college level as well both for students in math classes for pre-service teachers and for students in

developmental math classes (Hamman, 2005). Students were able to choose to tutor at local schools or after-school programs. Tutoring younger students changes preservice teacher students' attitudes about mathematics and increases their motivation to learn mathematics, making the service-learning program truly meaningful to all participants—future teachers and K-12 students alike.

These studies, taken together, reveal service-learning has positive impact on the learning within a mathematics course regardless of the students' major or mathematical ability. A collaborative effort between a university and an urban city school district allowed pre-service teachers to gain valuable classroom experience early in their careers (Ridlon, 2005). All tutors, regardless of major, felt a positive personal impact. Beyond simply improving children's mathematical skills, tutors became mathematical role models to the children they tutored, encouraging at-risk students to raise their expectations and think about attending college themselves. The tutoring of other students does not even need to extend to local school districts; it could take place within the college itself. Craig (2005) describes a project in which secondary mathematics education students developed a supplemental program for college algebra students at the same university. This provided pedagogical experience for the education students while at the same time assisting the math department.

Regardless of the student's mathematical ability, even in lower level mathematics courses and education courses, service-learning can be seen as quite beneficial not only to the cognitive learning outcomes of the course but also the affective appreciation of the material. The success of projects seems less tied to the level of mathematics involved and more tied to the organization of the project, with a focus on opportunity for reflection.

Connecting mathematics with service-learning to benefit not only the students but also the faculty member teaching the course as well as the university as a whole, there needs to be some reflective written and oral component with an established rubric (Schulties, M.S., 2011 & 2013). While there are a plethora of great examples of successful projects discussed above, many of which explicitly noted the effect of service-learning on student attitude and motivation, ultimately there is still a need for more research on the effectiveness of service-learning in improving student learning and in changing student attitudes about mathematics (Donnay, 2005).

We will now examine service-learning in mid-range mathematical courses while still considering classes with both math majors and non-math majors. Admittedly, there may be some courses here that can be argued belong in the preceding section (and vice versa), but hopefully these categories help provide some distinction on the nature of the service-learning projects involved these level of courses. Statistics courses will also be considered in this category as well. First we begin by mentioning the examples of discipline-based service-learning that exist in the research literature. The context of one such service-learning opportunity was in tutoring local urban high school students in related course material in three separate offerings of basic calculus courses over four years (Crisman, 2011). Students self-selected into this (one of several options) for a semester-long project. The significance of this article is Crisman's insistence on the deep reflective nature of service-learning. A goal of providing service-learning opportunities is to help students connect mathematics study with the rest of their lives. Given that much service-learning is motivated by concerns of a broadly moral nature, it is natural to ask students to specifically reflect on this aspect of their service. Crisman reports on this at

Gordon college, where student self-reports overwhelmingly did not just describe the service as having been mathematically helpful or a good thing to do, but as having given impetus to (broadly speaking) deeper moral reflection and formation. Reflecting on this placed their service in a personal (not just community) context, and provided a chance for students to explore their own ideas about why or how they are serving. This is a powerful example to consider. However, as with the previous section, much of the available research on service-learning in this area tends to shift toward problem-based service-learning. Massey (2005) presents a scenario in which service-learning was only limited to tutoring in public schools and remained discipline-based until the development of four data interpretation projects covering topics in college algebra, discrete math, pre-calculus for business and economics, and statistics. Radu (2013) describes the “Math in the City” program at the University of Nebraska. “Math in the City” is an interdisciplinary mathematics course in which students engage in real-world experience to understand current major societal issues of local and national interest. The course runs in collaboration with local businesses, research centers, and government organizations that provide data and act as consultants throughout the course. Radu notes that it is both the businesses and the students that benefit from their involvement in service-learning. In another long-term study, Shafii-Mousavi (2011) discusses how service-learning seems to have a positive impact on students’ attitudes and motivation in sharing a five-year team teaching experience of a non-major first-year mathematics course.

Although some of the above examples included a possible statistics component, as statistics lends itself very easily to the application of classroom material in service-learning, let us now examine pure statistics courses in greater detail. Bailey (2011)



describes three statistics courses all of which include some service-learning projects using real data. These three courses are: an introductory course for non-math majors, a course in probability and statistics for math/science majors, and an advanced statistics course (also for math/science majors). Bailey reports that many students say that participating in these projects not only helped deepen their understanding of statistics but made them feel like they were contributing to something important. Sungur (2005) notes the overall improvement of the statistics curriculum at the University of Minnesota, Morris. This improvement is not only in the content of the course but also in the structure of the course – in other words, service-learning doesn't simply add new knowledge to the students' cognitive repertoire, but it also benefits them in the affective experiences in which they engage. As far as the types of statistical projects that are undertaken, they can generally be categorized as client summaries, program assessments, or community surveys (Hydorn, 2005). Regardless of the form the service-learning project takes, the key, as with the previous section of courses, remains in the reflective component of the project. Statistics courses that require reflection on the meaning of data in contexts richer than classroom presentation can lead students to a deeper and more nuanced understanding of statistics (Root, 2005). Reed (2005) summarizes the benefits of using service-learning in statistics: the classroom becomes more experiential with active learning, the project provides richer examples for class discussion and the students more fully participate in these discussions. Furthermore, the students encounter the unexpected with real data that is not present in data sets in textbooks, which in turn provides them with opportunities to explore the application of ideas and concepts to new situations.

In summarizing the service-learning literature above in a math specific context, several points become very clear. First is that the vast majority of work in this area centers around looking through successful examples and then from the examples drawing inferences as to what about the projects made them successful. This leads to the common threads of quality organization and quality community partnerships, clear purpose/usefulness of results, and student buy-in to service being an essential aim of the course. It is also clear from the research that service-learning not only increases cognitive gains in students by in large, but it also works to form more positive attitudes and appreciation of mathematics.

### **Theoretical Framework**

The theoretical framework of this study builds primarily off of the work of Smith (2009). As Smith notes: “Behind every pedagogy is a philosophical anthropology” (p. 27). Before you can teach a human being you must first have a notion of what a human being is. Smith notes that a pedagogy that focuses on cognition, that sees education as primarily disseminating information, tends to assume human beings are primarily “thinking things” and cognitive machines. Smith’s thesis is that human beings are primarily affective beings before they are cognitive beings, and this anthropology bears itself out in the current educational system regardless of whether it is recognized. Smith describes education as not primarily a heady project concerned with providing information; rather, education is most fundamentally a matter of formation, a task of shaping and creating a certain kind of people (Smith 2009, pp. 26-27). Smith explains further that an education is a constellation of practices, rituals, and routines that inculcates a particular vision of what is good by inscribing or infusing that vision into the

metaphorical heart by means of material, embodied practices. For Smith, there is no neutral, non-formative education.

For Smith human beings are first and foremost creatures of desire before they are creatures of thought or even creatures of belief. Affections pull humanity through life toward our vision of “the good life” rather than cognitions rationally pacing out humanity’s steps. Humans are creatures of love, and love requires practice. In other words, affections are shaped by the practices/habits/rituals that people are immersed in. Smith refers to these as liturgies – rituals of ultimate concern: rituals that are formative for identity, that inculcate particular visions of the good life, and do so in a way that means to trump other ritual formations. While Smith offers much to unpack for educators, for the purposes of examining affect in mathematics education the following points are significant to note: 1) the argument that human beings are primarily affective rather than cognitive, and 2) affections are shaped by practices (liturgies). An example of what an embodied practice might look like in the math classroom: if a teacher poses questions to the class on a regular basis and simply responds “no” to incorrect answers, moving quickly to a student who can give the correct answer rather than dwelling on *why* the incorrect response is incorrect, then to the students in that class math is now only about having correct answers. Alternatively a teacher who spends time addressing what is still valuable from the mathematical reasoning of the student who is incorrect, and who validates the student’s effort, instills the perspective that mathematics is primarily about the reasoning process itself rather than simply arriving at the correct solution.

The importance of affect and its positive development through habits, practices, and routines as noted in the above research ties in directly to the development of positive

disposition in classroom settings. Gresalfi and Cobb (2006) define learning as a process of developing dispositions – ways of being in the world that involve ideas about, perspectives on, and engagement with information that can be seen both in moments of interaction and in more enduring patterns over time. Thomas and Brown (2007) note that dispositions involve “attitudes or comportment toward the world” and are “generated through a set of practices which can be seen to be interconnected in a general way” (p. 8). In mathematics education, specifically, it has been argued that the modification of student belief structures comes not through addressing content but through sufficiently rich educational practices (Goldin, 2002). McClosky (2014) proposes ritual analysis as a lens for viewing the math classroom as a series of embodied practices that rise above a purely rational enterprise. The specific practice, or ritual, of guided reflective activities has been demonstrated to increase student appreciation of a given subject (Hulleman, 2010).

Combining Smith’s view on liturgies with the emphasis on the ability of reflective processes to impact student value systems in the classroom as proposed by Hulleman (2010), it becomes clear how service-learning might serve to best impact the affective learning of students in the mathematics classroom. Hadlock (2005) stresses the importance of regular (habitual) practices of reflection throughout service-learning activities. Service-learning will be studied as a viable means to cultivate mathematical affections of students by providing a habitual practice of reflection in an educational context where the aim of the project is not primarily the increase of student cognition.

### **Conceptual Framework**

The conceptual framework of this study will center on research question 2: What is the alignment between the affective objectives of national policy documents on the

aims of mathematics education and the affective outcomes on students participating in a service-learning project? Specifically this study will focus on the description of “productive disposition” offered by the National Research Council in *Adding it Up: Helping Children Learn Mathematics* (2001). Productive disposition is defined as “the habitual inclination to see mathematics as sensible, useful, and worthwhile” (p. 116). The collected data will be analyzed as to how it gives evidence of students seeing mathematics as sensible, recognizing the usefulness of mathematics, and understanding mathematics as a worthwhile task to be performed.

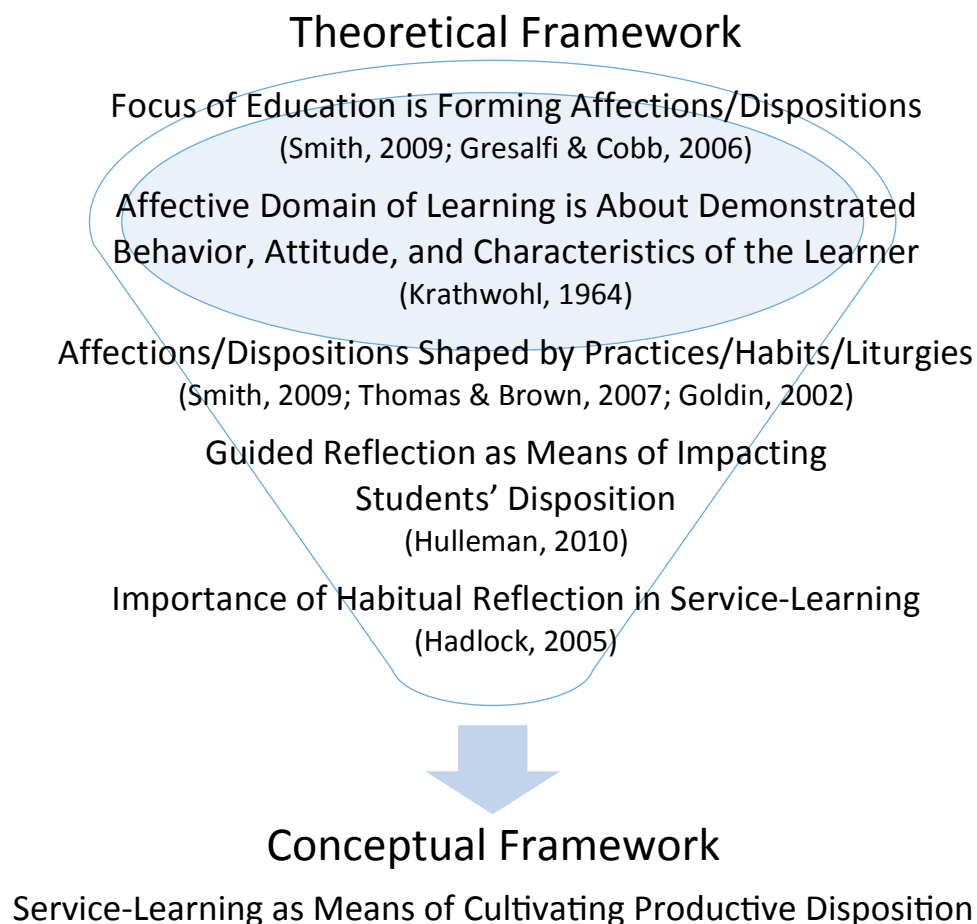


Figure 1: Theoretical and Conceptual Framework

## **CHAPTER III: METHODOLOGY**

### **Introduction**

The overall goal of this study was to describe the development of affect in students within the context of a mathematics classroom as students engage in a service-learning project. This affective development was analyzed through the above theoretical framework with a particular emphasis on examining the impact of regular guided reflective practices on student valuation of mathematics. The study answers the following research questions:

1. To what extent does service-learning impact the cultivation of mathematical affections among students?
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?

The nature of the affective domain of learning lends itself naturally to being examined through qualitative methods. This particular study was not intended to quantify affect in students but rather to offer a description as to how affect forms in students as they engage in service-learning. The descriptive nature of this study made a qualitative approach more appropriate, however some quantitative data was gathered as well. Goldin (2014) distinguishes between *traits* that characterize different individuals' typical affective responses in mathematical situations, typically studied quantitatively through

surveys, and *states* that refer to affect in the moment when doing mathematics, typically studied qualitatively through interviews. As noted in the definition of *disposition* given above by Gresalfi and Cobb there is both a *trait* and a *state* component to be considered.

In particular this study was conducted as a case study, focusing on a select group of five students in a high school mathematics class as they engage in a service-learning project. The students were high school seniors and juniors in an AP Statistics class. As a course project, all students, regardless of participation in the research component, participated in a group which provided the following four service components: meeting with a non-profit agency and developing a survey instrument, conducting the survey, compiling data and performing statistical inference procedures, and presenting results. All students completed a shortened version of the Fennema-Sherman Math Attitudes Scale (FSMAS) (Fennema & Sherman, 1976; Mulhern & Rae, 1998) at the end of the fall semester, prior to the assignment of the service-learning project. From the responses to the FSMAS, a small group of students was identified to be the members of the case study.

The experience of these students was documented through observations (primarily of students as they interacted with one another in their group and the ways in which they interacted with the partner service organization), student interviews, and collected artifacts (such as weekly reflection journals employed throughout the project as seen in Appendix C). All students in the course participated in the reflection journal component of the project but only the responses of the students in the case study were analyzed thoroughly. The observation framework was based on the work of Schorr and Goldin (2008) in researching student affect in a math classroom – it focused on the visible student cues that could lead one to infer the affective engagement of the student (See

Appendix D). The interview protocol was shaped based upon prior student interviews over a service-learning project from the pilot study. Finally, the artifacts that were collected were designed around successful examples of reflection guides as presented by Hadlock (2005) and other appropriate research on service-learning in a mathematics context.

Again continuing in the same vein as Schorr and Goldin (2008), while the data collection process followed the guidelines of a case study, the data analysis followed more of a grounded theory approach. The goal of the study was to document fully the experience of the selected students as they engaged in a service-learning project (with particular emphasis on the development of affect) and then from this data offer a proposed general description as to how mathematical affect forms in students involved in service-learning. The initial gap in the existing literature on affect in mathematics education is the absence of a description as to how to go about forming the desired affections of students. The ultimate purpose of this study was to address this question particularly within the context of service-learning. The hope is that future research may then be able to explore how affect is developed (or not developed) by comparison within the context of the “typical” classroom approach. It is also suggested that a broader theory on affect should be developed that recognizes the primacy of affect to cognition. This study is meant to offer some supporting evidence upon which that theory can be developed.

## **Design**

This study was conducted as a case study, focusing on a select group of students in a high school mathematics class as they engaged in a service-learning project. A case study is an exploration of a “bounded system” or case (Creswell, 1998). According to



Creswell (1998), the case being studied is bonded by time and place and can consist of a program, event, activity, or individuals. In this study the case is bounded by the 2015-2016 academic school year, the location of the school and the descriptions of the students: the students were all high school seniors and juniors in an AP Statistics class. The particular case in question focused on the affective response of the individual students involved in the service-learning activity. Because the true focus is on the broader issues of cultivating mathematical affections and service-learning, this study served as an instrumental case study (Stake, 1995), using the experiences of these students to illustrate broader issues.

Recall, as a course project, all students participated in a group which provided the following four service components: meeting with a non-profit agency and developing a survey instrument, conducting survey, compiling data and performing statistical inference procedures, and presenting results. All students completed a shortened version of the FSMAS (included in Appendix A) in the fall semester, prior to the assignment of the service-learning project. Though the FSMAS asks students to respond on a Likert scale in response to a series of statements regarding attitude in mathematics (as will be explained further in the “Instruments” section below), for the purposes of this project the modified FSMAS data was analyzed qualitatively rather than quantitatively. The FSMAS has significant influence in current research on affect (Wilson, 2011, p. 68) and hence its inclusion in this study. However there has been significant disagreement on the use of quantitative measures in assessing affect. McLeod (1994, p.640) notes that “complicated statistical analyses of questionable questionnaire data have not necessarily been reflecting accurately what students have been thinking and feeling.” In relation to research on problem solving, narrative and interpretive methods are being more widely used for assessing attitude

(Larsen, 2013, p. 4). The student responses to the FSMAS survey simply provided a starting point for assessing which students might provide the richest descriptions of their affective experience in mathematics and it also allowed students with a variety of initial attitudes to be selected in a sample for further study.

From the student responses to the FSMAS, a group of 10 students was identified for in-person interviews. The following variables were considered when selecting the group of 10 students: gender, grade level, section of course, achievement level in the course, FSMAS scores, and whether or not I had taught the student previously in a math course that involved a service-learning project. The intention was for students to be selected in a way that that makes the case study group representative of the classes as a whole. Table 2 below summarizes the characteristics of these ten students.

Table 2: Summary Characteristics of Ten Representative Students in Study

Student	Gender		Grade Level		Course Section		Achievement		FSMAS Scores			Previously Taught	
	Male	Female	Junior	Senior	A	B	High (85 average and above)	Low (Below 85)	High (top third)	Medium (middle third)	Low (bottom third)	Yes	No
1		X	X			X	X			X		X	
2		X		X	X			X		X			X
3	X		X			X	X		X			X	
4		X		X	X		X				X	X	
5	X			X		X	X		X			X	
6		X		X		X		X			X	X	
7	X			X	X			X			X		X
8		X		X		X	X				X	X	
9	X		X		X		X			X		X	
10		X		X	X			X			X		X
Total	4	6	3	7	5	5	6	4	2	3	5	7	3

This group of students was selected for interviews as a follow up to their survey responses. The interview protocol emerged from their responses and was primarily aimed

at having students provide a narrative for their reasoning in their survey responses. The interview protocol can be found in Appendix B.

As the students engaged in the service-learning project throughout the course of the school year, the experience of these students was documented through observations (primarily of students as they interact with one another in their group and the ways in which they interact with the partner service organization), student interviews, and collected artifacts (such as weekly reflection journals that are employed throughout the project). At regular intervals throughout the year, students were allowed a project workday in class. These workdays formed the basis of the collected observations. The ten students above were interviewed prior to the assignment of the project and in response to their responses on the FSMAS survey. As mentioned, this initial interview aided in determining which small group of students to focus on for this case study. This group of students was selected in a way that that makes the case study group representative of the classes as a whole. These ten students were also interviewed near the close of the spring semester. While the project proceeded throughout the course of the year (see appendix C for details on the project calendar), the bulk of the statistical work was done in the spring after students learned some basic techniques of statistical inference. Therefore the initial student responses to the introduction of the project throughout the fall semester were monitored for all ten students above through observation, interviews, and collected reflection journals. This gave a full perspective on these ten students' starting points in terms of mathematical affections and how their affections were being impacted by the project. At the close of the spring semester, a small group of five students was selected as

the focus of the case study that provided the most rich and varying descriptions of their experience in the project.

All students in the course (N=44) participated in the reflection journal component of the project throughout the course of the entire year as it has been noted that the reflective process is vital for students to gain the most from a service-learning experience (Webster & Vinsonhaler, 2005, p. 257). However, from the spring semester onward, only the responses of the students in the case study were analyzed thoroughly. Again continuing in the same vein as Schorr and Goldin (2008), while the data collection process followed the guidelines of a case study, the data analysis followed more of a grounded theory approach. The goal of the study was to document fully the experience of select students as they engage in a service-learning project (with particular emphasis on the development of affect) and then from this data offer a proposed general description as to how mathematical affect forms in students involved in service-learning.

Middle of Fall Semester	<ul style="list-style-type: none"> <li>• Project assigned</li> <li>• FSMAS administered to all students</li> <li>• Students meet representatives from the partnering organization and begin forming survey</li> </ul>
End of Fall Semester	<ul style="list-style-type: none"> <li>• Students finalize survey</li> <li>• Students have completed five reflection journal entries since beginning of project</li> <li>• Observations have taken place during class work days throughout semester</li> <li>• Initial interviews of 10 students takes place</li> </ul>
Beginning of Spring Semester	<ul style="list-style-type: none"> <li>• Students develop proposal for administering and analyzing survey</li> </ul>
Middle of Spring Semester	<ul style="list-style-type: none"> <li>• Students administer survey and begin analyzing results</li> </ul>
End of Spring Semester	<ul style="list-style-type: none"> <li>• Students finalize reports</li> <li>• Students present findings to partner organization</li> <li>• Students have completed 10 reflection journal entries for the spring semester (15 overall)</li> <li>• Observations have taken place during 10 class work days throughout semester</li> <li>• FSMAS administered again to all students</li> <li>• Final interviews of group of 10 students take place</li> <li>• Group of 10 is narrowed to group of 5 for data analysis</li> </ul>

Figure 2: Summary of Time Frame for Student Project

## Setting

The setting for this study is a suburban private high school in central Texas. The students involved in the study are a mix of juniors and seniors in an AP Statistics course. As a pre-requisite for the course, every student must have completed at least through Algebra II successfully. While all students meet the minimum pre-requisite mathematical knowledge, the mathematical experience of students enrolled in the course is varied; from those who have recently just barely passed Algebra II up to those who are concurrently

enrolled in AP Calculus. The content of the course follows the prescribed curriculum for AP Statistics given by the College Board and includes the following topics:

- Exploratory Data Analysis: Planning a study, including deciding what to measure and measurement methods that minimize bias.
- Data Collection: Exploring and describing data by searching for quantifiable patterns and departures from patterns.
- Probability: Anticipating patterns, which include producing models using probability theory and exploration of distributions.
- Statistical inference: Includes developing confidence intervals and performing tests of significance.

Each of the major four topics above were addressed in the course service-learning project. A description of the project (including a grading rubric and calendar) as it was presented to students is included in Appendix C.

It should be noted that while the mathematical background of students in the course was varied, the socio-economic background of the students is rather homogeneous by the nature of attending this particular private school. This is one notable drawback of this study: that it does not address students from varying socio-economic situations. Another important factor to consider by conducting this study with students at a private school is that this particular private school has an expectation of service on the part of the students. Community service is not foreign to these students and many have years of experience with it. However, as noted in the literature review above, there is a difference between community service and service-learning. In service-learning the content of an academic course is integrated into the service requirement placed on students. In that respect, these students do not have extensive experience with service-learning, though it must be noted that it is possible some students may have experienced true service-learning before coming to this class and that information was noted.

The organization that students partnered with on their service-learning project (henceforth referenced as “the partner organization”) is a homeless outreach program in a central Texas city. The partner organization operates under a philosophy that homelessness is more than house-less-ness, it is rather a severe break in community from others. The partner organization purchased land just outside of the city on which they developed a community of affordable housing for the chronically homeless. This property also has amenities such as a gardening center, small livestock animals such as chickens and goats, a health clinic, a carpentry workshop, and a meeting space for continuing education and other such classes. Everything about the property is designed to foster a sense of complete community.

The founder and president of the partner organization was interested in joining with the students in the AP Statistic course to complete a study based largely on Bruce K. Alexander’s “Rat Park” experiment (as referenced in Hari, 2015, p. 170ff).<sup>3</sup> Basically, seminal studies that had proven the addictiveness of drugs such as heroin (and others) had done so through administering the drug to rats in cages in isolation. Alexander set up a study in which the rats were allowed to operate in community and found that the amount of drugs consumed went down drastically, indicating that environment and community (or lack thereof) can play a significant role in drug use. The partner organization was interested in seeing if the residents of their community will have the same response as the rats of “Rat Park.” The partner organization was interested in having students survey the residents of their new community development on issues related to their life on the streets

---

<sup>3</sup> Though not referenced here, see also: “The effect of housing and gender on Morphine self-administration in rats.” *Psychopharmacology*. 58, pp. 175-179. and “Effect of early and later colony housing on oral ingestion of morphine by rats.” *Pharmacology, Biochemistry, and Behaviour*, Vol. 15, pp. 571-576.

(physical, psychological, and spiritual) prior to moving to the new community and how those issues may have changed since moving to the community. So for instance, has the drug use among the occupants of the property significantly decreased in comparison to their life on the streets in isolation? With this basic premise, the students were tasked with developing the complete survey, methodology, and appropriate analysis as part of the service-learning project.

### Sample

As indicated above, the sample for the case study came from the students enrolled in AP Statistics at a suburban high school in central Texas. The course typically has two sections of around 20 students each. Based on information collected from all the students from the FSMAS survey and initial fall interviews, in the spring, a small group of five students was determined in order to gather the richest and most complete description of the student experience of the service-learning project. This group of students was selected in a way that that makes the case study group representative of the classes as a whole.

Table 3 below summarizes the characteristic of the final group of five students for this case study. Please note that the names given below are pseudonyms.

Table 3: Summary Characteristics of Five Students in Final Case Study

Student	Gender		Grade Level		Course Section		Achievement		MAS Scores			Previously Taught	
	Male	Female	Junior	Senior	A	B	High (85 average and above)	Low (Below 85)	High (top third)	Medium (middle third)	Low (bottom third)	Yes	No
Tabitha		X		X	X			X		X			X
John	X		X			X	X		X			X	
Ava		X		X	X		X				X	X	
Mason	X			X	X			X			X		X
Charlotte		X		X		X	X				X	X	
Total	2	3	1	4	3	2	3	2	1	1	3	3	2



## **Instruments**

### *Surveys*

Prior to assigning the project, every student was asked to complete a modified version of the FSMAS. A sample is included in Appendix A. As noted, the FSMAS has significant influence in current research on affect and hence its inclusion in this study. The FSMAS was developed with a focus on exploring research into gender differences in mathematical engagement and consists of nine sub-scales: Attitudes towards success in mathematics, Mathematics as a male domain, Confidence in learning mathematics, Effectance motivation in mathematics (the motivational aspects of competence), Usefulness of mathematics, Father (concerning the father's perceived opinions/beliefs/attitudes), Mother (concerning the mother's perceived opinions/beliefs/attitudes), Teacher (concerning the teacher's perceived opinions/beliefs/attitudes), and Mathematics anxiety (Wilson, 2011, p. 68).

There are many examples of studies on affect being completed using a modified version of the FSMAS (Mulhern & Rae, 1998) or new instruments developed based on the FSMAS (Larsen, 2013, p.4). This study also used a modified version of the FSMAS in order to shorten the length of the questionnaire from its original 108 questions and also to deal specifically with the domains most associated with general affect and not on gender specific issues. The scales of "math as a male domain," "father," "mother," and "teacher" were discarded since their focus was on gender differences and the perception of mathematics the students had based on the people in the environment around them. For this study, the only focus is the affective dimensions of learning experienced by the students and how they change from the beginning of the project through the end (and not concerned with where these affections were initially instilled in students). The "attitudes toward success in

mathematics” scale was also discarded as it had to do with how students felt they were perceived by their peers and not on the mathematical content at hand.

The scales that were retained were “confidence in learning mathematics,” “effectance motivation in mathematics,” “usefulness of mathematics,” and “math anxiety.” Within in these scales statements were retained that most similarly reflected the intent of commonly used questions in service-learning reflection (see Appendix C). At least one positively worded statement and one negatively worded statement was retained for each scale and the same amount of each was retained within each scale. The positive statements are graded on a Likert scale of 1 to 5 with 1 indicating strongly disagree and 5 indicating strongly agree. The negative statements are also graded on a Likert scale but the 1 and 5 distinctions are reversed, with 1 being strongly agree and 5 being strongly disagree. This allows high scores to always indicate a positive response and low scores to always indicate a negative response.

As mentioned, the modified FSMAS was not analyzed (in any significant way) through quantitative methods due the general untrustworthiness of quantitative methods to capture affective responses in students (McLeod, 1994). However, the responses provided a general baseline for the initial level of mathematical affections held by each student. The modified FSMAS also formed the basis of the initial interviews conducted with students to gather a narrative description that can be analyzed qualitatively. The survey was given again upon the completion of the project. Any significant quantitative changes were noted (and can be found in Chapter 4), but primarily the survey again acted as a jumping off point for student interviews that offered a qualitative description.

### *Observation protocol*

Observing affect is inherently difficult. The observation framework was based on the work of Schorr and Goldin (2008) in researching student affect in a math classroom –

it focused on the visible student cues that could lead one to infer the affective engagement of the student (See Appendix D for complete observation framework). Schorr and Goldin sought to study episodes where key affective events occurred in the context of conceptually challenging mathematics with the purpose of characterizing instances where there is evidence for powerful affect—patterns of emotions, attitudes, beliefs, and values that foster engagement, persistence, and success (p. 135). By conceptually challenging mathematics, Schorr and Goldin meant mathematical activity involving the need for a new conceptual understanding and/or for conceptual change; where students are likely to experience the need to “figure something out,” or to have a sense of impasse (Ibid.). They also define a key affective event to be an occasion, in the context of doing or discussing mathematics, where significant affect or a significant change in affect (of a student or the teacher or across the class) is expressed or can be inferred (Ibid.). Examples include moments of frustration, anger, or withdrawal, as well as moments of engagement, elation, delight, or satisfaction.

Following Schorr and Goldin, key affective events were the focus of observation. As students were given in-class workdays in which to work on their project with their groups, as the instructor, I was able to move about the classroom and monitor student interactions with other students and with the project material. By Schorr and Goldin’s definition above, the entire project presents students with conceptually challenging mathematics and so the project workdays were ideal times to observe key affective events. After the key affective event was observed field notes were taken on the students words and actions as they processed through that affective moment until it was resolved

in some fashion. This process was repeated through the class workdays during the course of the project.

### *Reflection Journal*

Reflection is essential for any well-designed service-learning project (Hadlock, 2005). Every student in the class was expected to maintain a reflection journal through the course of the project and regularly updating said journal was considered part of the overall project grade (See Appendix C for reflection prompts and Appendix G for project rubric). The school assigns every student a student email account through Google. A Google Drive document was created for every student and served as their reflection journal throughout the project. This electronic journaling served as an easy way for the instructor to ensure that the students were updating their reflections in a timely manner. The project required students to update the journals at minimum every two weeks for a total of five reflection entries in the fall semester and ten reflection entries in the spring semester. The reflection questions are included in Appendix C and are modified from the work of Webster & Vinsonhaler (2005). Students generally had the option of responding to questions of their choosing or to simply reflect on their own. Occasionally, at certain key points of the project, the instructor asked every student to respond to one question in particular.

### *Interviews*

Interviews were conducted toward the end of the fall semester and then again at the close of the project. Every student in previously described representative group of ten was interviewed both times. The interviews in the fall aided in determining which

students were the focus of the case study in the spring – the final group of five. Only the interviews from the final group of five students were included for qualitative analysis.

The fall interviews were based first on student responses to the modified FSMAS survey, asking them to add narrative to their quantitative responses to the survey. By the end of the fall semester the students had completed the design phase of their service-learning project. In keeping with the prompts from the pilot study, students were asked to describe their experience in the project thus far. See Appendix B for the beginning of project interview prompts. The spring interviews were again based on the responses to the second FSMAS survey students completed at the close of the project, asking them to explain the reasoning of their response or to get them to clarify why certain responses might have changed as compared to the fall. Finally the spring interview asked them to describe their experience on the project as a whole now that it has been completed. See Appendix E for the end of project interview prompts.

Below, Table 4 summarizes the research questions of this study and the manner in which data was collected and analyzed to assess the outcomes of this project.

Table 4: Summary of Research Questions and Methods of Measurement

Research Question	Variable	Indicators	Measurement
1. To what extent does service-learning impact the cultivation of mathematical affections among students?	Development of Productive Disposition tied directly to involvement in community experience	<ul style="list-style-type: none"> <li>• Role of community experience in learning</li> <li>• Role of community experience in engagement</li> <li>• Changes in perspective on course content</li> </ul>	Interviews Surveys Reflection Journals
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?	Understanding course content (Sensible)	<ul style="list-style-type: none"> <li>• Role of community experience in understanding course content</li> <li>• Perceived relevance of community experience to course content</li> </ul>	Interviews Surveys Reflection Journals Observed interactions with students and instructor
	Applying course content (Useful)	<ul style="list-style-type: none"> <li>• Role of community experience in applying course content</li> <li>• Recognition of practical application of course content</li> </ul>	Interviews Surveys Reflection Journals Observed interactions with community partner
	Valuing course content (Worthwhile)	<ul style="list-style-type: none"> <li>• Role of community experience in producing a rewarding sense of work committed to course content</li> <li>• Recognition of community experience to sufficiently important to justify effort spent</li> </ul>	Interviews Surveys Reflection Journals
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?	Cost/Benefit analysis on the feasibility of implementing community experience	<ul style="list-style-type: none"> <li>• Recommendation to utilize community experience in other courses</li> <li>• Valuing time spent on community experience over against traditional methods of learning</li> <li>• Drawbacks of community experience</li> </ul>	Interviews Surveys

## Data Collection

The initial modified FSMAS survey was administered early in the fall semester, several weeks into the school year yet prior to the formal assigning of the service-

learning project. This gave the students time to settle into the rhythms and routines of the classroom and to have an initial sense of the material that is covered in AP Statistics. The project was formally assigned after the completion of the first unit in the course. The first unit covered how to design a study. By waiting until after the completion of the first unit to assign the project the students were equipped to handle the first steps of the project: designing a survey instrument for the study. The remainder of the fall semester was spent refining and piloting the survey instrument with the intention of gathering the data early in the spring semester, analyzing data by the middle of the spring, and having a conclusion and presentation at the end of the spring semester.

Toward the end of the fall semester ten representative students were interviewed (as previously described). The interview prompt stemmed from their responses to the FSMAS survey and it also asked them to describe their experience with the beginnings of the project through the fall semester. From the surveys and fall interviews a group of five students was selected by the close of the fall semester for further analysis in the case study during the spring semester. This group of students was selected in order to provide a rich and varied description of the project through the spring semester (as described previously).

From the beginning of the project assignment in the fall semester until the end of the year, students were expected to keep updated reflection journals with entries every two weeks – five total entries in the fall and ten total entries in the spring. The school issued every student a student email address through a Google account. A Google Document was created for every student and served as their reflection journal throughout the year. This electronic journaling made it easy to check that every student has been

updating it appropriately. The entries during the fall semester aided in determining the group of students to be the focus of the case study. Only the journal entries for those students in the case study were significantly analyzed for the final results.

At the close of the project at the end of the spring semester every student was again given the same modified FSMAS survey they were given in the fall and any significant differences were noted, but not analyzed quantitatively. Rather, the responses to the spring survey served as the basis for the final interviews that were conducted on every student, but only qualitatively analyzed for the students who were the focus of the case study.

### **Data Analysis**

From the initial FSMAS survey responses, fall interviews, and fall reflection journal entries, a group of five students was chosen as the focus of the case study. These students were selected so as to provide for varying initial positions in regards to their attitude toward mathematics or service-learning (as indicated previously). The students were selected who provided evidence of providing rich descriptions of their thought process and affective changes.

The student interviews, field observations, and collected reflection journals were coded in a similar manner to the pilot study, following the three major themes of a productive dispositions: seeing math as sensible, useful, and worthwhile. These codes initially derived from the definition of a productive disposition offered by the National Research Council (2001), followed in the vein of Jansen (2012), and were confirmed as these themes emerged through an open coding of the pilot study interviews. The fourth theme that emerged from the pilot study of relationship building was also included in the



coding of the data from this project. While these four codes were used, open coding was also used to see if any further themes emerge from the collected data.

In addition the Likert responses to the FSMAS surveys given at the beginning of the year to every student were compared to the responses of every student at the end of the year. The proportion of students who improved their responses (increase in positive attitude) was recorded.

### **Limitations**

One of the major limitations of this study is that I as the researcher am also the instructor of the course in which the students were performing the service-learning project. I functioned as a participant observer, immersed in the daily school lives of the students in this study (Creswell, 1998). Participant observation is a method of qualitative data collection typically ascribed to an ethnography (Creswell, 1998), in which the focus is on examining a group's patterns of behavior. This study was not interested in discovering the meanings of behavior or culture-sharing interactions amongst students, but rather in examining the students' experience in a bounded service-learning activity. This makes a case study approach more appropriate. In general, the participant observer is concerned with employing multiple overlapping data collection strategies: being fully engaged in experiencing the setting while at the same time observing and talking with other participants about whatever is happening (Patton, 2002). While I participated with the students throughout the service-learning project, I did not participate in exactly the same fashion as I did not take on the role of student myself. As the instructor I had some level of separation from the participating students during the research process.

One potential area for concern is that the students may have felt beholden unto me to provide positive responses either to the FSMAS survey or to qualitative measures during the study such as the student responses in reflective journals or in interviews. It was made clear to students from the very beginning (and students were reminded throughout the project) that their responses to the FSMAS survey, journal prompts, or interview questions had no bearing on their final grade on the project or in the course. One key component of the service-learning project was to organize it in such a way as to have the partner organization have a significant say in the evaluation of the final project. In this way I hoped to be seen as a facilitator in the partnership between the partner organization and the students and not the ultimate authority on the project. This hopefully provided students an opening to share both positive and negative responses with me, viewing me as someone who is on their side to help develop the best product possible for their client, the partnering organization. In addition to the structuring of the service-learning project so as students don't feel beholden unto me as their instructor, I also have the benefit of an established history with this course at this school. This was my fourth year teaching AP Statistics at this school and a service-learning project, including aspects of reflection and student experience surveys, has been utilized every year. The part and parcel of the course was not changed in order to gather data for this study. Though more reflections were asked of students this year than in previous years, reflection is not a new component added to the course. In other words, the amount of work of type of responses required of the students was not affected by their involvement in the study, thus opening the door for them to respond freely as students have for the past several years.

Another concern in this study is the effect I have as an inquirer and the extent to which the predispositions or biases of the evaluator may affect data analysis and interpretations (Patton, 2002). As the researcher, I was sure to clearly state my own previous experience and disposition toward service-learning in the final data analysis. Rigorous data collection and analytical procedures like triangulation are aimed at substantiating the validity of the data and minimizing the inquirer biases (Patton, 2002).

Finally, one additional limitation is that this study was performed on AP Statistics students. While AP Statistics is offered as a math course there are some clear distinctions between the disciplines of mathematics and statistics. So, one may wonder if this study is about cultivating statistical affections rather than mathematical ones. While there admittedly is a distinction between statistics and mathematics at higher levels of education (post-secondary and beyond), what is important in this study is the perception of the students involved. AP Statistics is offered as a math credit, taught in a math classroom in the mathematics wing of the school building, and has a math pre-requisite of Algebra II. While students' views on statistics as separable from the discipline of mathematics may evolve over time, it is safe to assume that as juniors and seniors in high school that distinction has not yet been made – making the results of studying service-learning in a statistics course applicable to other secondary mathematics courses.

### **Pilot Study**

Several years ago I instituted a service-learning project while teaching AP Statistics at a rural Texas high school. The summer prior to that school year Texas was struck by an unusually large amount of wild fire activity – some of which occurred in the community where I taught. Many students in my AP Statistics class had friends and

family that were displaced by the fires and lost everything. When I proposed a spring project for statistics that was going to be service-based and tied in to the local community, the students overwhelmingly determined to focus their attention to helping the victims of the fire. Ultimately the students settled on comparing the effectiveness of the city in responding to the needs of wild fire victims with the effectiveness of local charity outreaches. The project garnered a lot of attention from the community and the students ultimately presented their results in front of the city council. The school district where I taught decided to make a promotional video highlighting this project for the district website and other media outlets. The media director for the district took a sample of students from the class and interviewed them about their experience with the project, using a few sound bites in the final version of the video. A copy of the unedited interviews was provided to me by the district upon the completion of the video. These are the interviews that have been transcribed and included in this pilot study data analysis. The long-term goal of analyzing these interviews was to form a framework for developing an interview protocol for a full study (that also includes observations of students and an analysis of student artifacts). The themes that arose in those interviews informed the focus of the present case study and the types of questions asked of the students involved in the process.

### *Data Collection*

As indicated above, these interviews were conducted by media director for the district. The stated goals of the district were to highlight the increased engagement of students, the greater control given to students over their learning outcomes, and the facilitation of deeper conceptual understanding of the material (Navasota Independent

School District: Learning, Leading, Succeeding Blog

(<http://www.learningleadingsucceeding.com/2012/06/evaluating-patronage-and-deliverance.html> Accessed March 24, 2015). These goals were the driving force behind the questions that were asked of the students. As seen in the transcripts, the interviewer does not stay consistent with wording for each student, but generally focuses on the same issues for each student. Working back through the interviews, it would seem that the students were asked some version of the following questions:

1. What is your impression of service-learning in general as a way to engage in a class in comparison with more traditional classroom methods such as lectures?
  - a. If another teacher was considering doing something similar to this project with their students, based on your experience, would you recommend that they do so? Why or why not?
  - b. How was working on something that was relevant to the community beneficial to you as a student?
2. Describe your experience as you have moved from the beginning of the project until now.
  - a. Did the project unfold the way that you expected it to?
  - b. What difficulties or hurdles did you face in this project?

I have grouped the sub-questions (a and b) beneath questions 1 and 2 as it seems that those questions were other ways of phrasing the main question the interviewer was interested in gathering information/sound bites on. The first question is clearly meant to elicit a response from the student that will speak to their engagement in the project. The

second is a general question aimed at having students describe their experience in their own words.

### *Data Analysis*

The major themes that emerge from examining the interviews are very much aligned with the description of productive disposition: students indicate that they are seeing math as sensible, useful, and worthwhile. These three concepts are very much interrelated and many of the cited quotes below reveal how one of these areas very easily bleeds into another. However, for the purposes of attempting to organize this data analysis each of these components of productive disposition will be treated separately.

Key indicators that showed students saw mathematics as sensible were phrases that indicated that the students viewed service-learning as a viable means for learning the material. In other words, through the service-learning process the mathematics made sense or could be seen as sensible. This type of response can best be typified by Student 11 who indicated: “You know, personally I believe that we learn a lot more through this process because of the fact that you don’t just ask the teacher questions, you ask your fellow students questions a lot. For me, I can honestly say that I was little bit more curious.” It was common for students to respond that their overall impression of service-learning was that it aided them in their understanding of the material. Student 1 noted: “when you have to do something, you’re going to remember it. You’re going to remember this like actually having to do that project in high school. ‘Oh I know how to do that. I did that.’” The indication here is that the results of a service-learning project will have a lasting impact on their understanding of the subject. Student 3 noted the benefits of the participatory aspect of service-learning as a key factor in developing a

deeper understanding of statistics: “I think it was probably one of the best things I’ve learned since I’ve been in high school because usually you just sit in a classroom with textbooks and lectures, but this way, you’ve got everybody in the classroom involved because you... had to participate.” Other general comments on students’ ability to have a deeper understanding of the sense of the material ran along the lines of “I learned a lot more that way than I did over his lectures” and “I think it’s a great way for students to get a better understanding of the material.” All of these comments also reiterate the position of much of the previously discussed research that affect cannot be completely divorced from cognition. In moving forward from the pilot to a complete study it will be important to keep this in mind. Affect is separate from cognition but not independent of it. The student comments also seem to indicate that affective aspects of the project (the physical engagement in routine that differs from a traditional lecture) are in fact the triggers for the cognitive gains that students experience and not vice versa. It is not because the student learned more that they then developed this stage of their productive disposition, but rather they engaged first at an affective level and this led to solidifying their cognitive understanding. This point will need to be brought out with greater detail and data support in the full study.

Key indicators that showed students saw mathematics as useful were phrases that indicated that the students viewed service-learning as a viable application of mathematics. In other words, through the service-learning process the students were more engaged in hands on application and came to see mathematics as being applicable and useful to everyday life. This general theme of usefulness or student engagement in application can certainly be attributed to the phrasing of the questions and the stated aims

of the interviewer as mentioned above. Since the end goal of the interviewer was to make and market a video, questions were asked in a leading way that were aimed to have students respond about an increase in their engagement level. However it is significant that every student when asked to compare service-learning with traditional classroom methods made some comment to the effect that they were more mentally involved in the process of learning during the project. The modifier “actually” was used extensively throughout the interview, as in students saying they “actually had to go do something.” This type of phrasing portrays an implicit understanding of the traditional classroom as a passive learning experience. Students indicated that through this project more of the onus for learning was placed on their shoulders and they spoke of that in a positive light. Another recurring phrase was students indicating their preference for doing something “hands on.” This indicates a benefit not simply in shifting the onus of learning to the student but also in having a component of that learning that involves physical application. Another common reference to “real-world application” helps support this notion of students learning more from doing, statistics in this case, in a life-application setting as opposed to simply hearing about statistics in a classroom environment. Apt quotes on this theme come from students 9 and 10. Student 9 noted: “By doing this we are taking it out of the classroom and applying it in real-life situations and we’ll be able to utilize it later on down the road because we’ve used it before in a situation other than just a test or a quiz or a worksheet.” Student 10 noted: “We got hands-on learning. We got to learn how to communicate with other people, go out and actually tackle a project. It wasn’t something in the class, it was something we had to do on our own time, and it was a lot of responsibility.” As in the first theme of seeing mathematics as sensible, a key observation



is that students appear to be engaged at an affective level primarily. The changing of routines, or habits of the math classroom (what Smith would call “liturgies,” 2009) seem to engage students at a visceral, pre-cognitive level and work to develop this affective productive disposition.

Key indicators that showed students saw mathematics as worthwhile were phrases that indicated that the students viewed service-learning as a valuable or enjoyable experience. In other words, through the service-learning process the value of the end result of the mathematics was clear and could be articulated by the student. The worthwhileness of service-learning is evident in student interviews in several ways. Many students discuss the increased sense of community, of building better relationships. Student 6 states “It kind of brings everybody together no matter what you're doing. If you're part of the class you're part of a group. And you know, it's a lot of fun.” To which the interviewer responds (unexpectedly) with “That’s great insight.” This idea of relationship building will be discussed in greater detail as its own separate theme below, but it lends itself to instill a sense in students of the value of what they achieved through the service-learning project – they believe they are better for having done it. Other comments that indicate the valuableness of this service-learning activity were comments of overcoming obstacles and the satisfaction that came with those achievements. For instances Student 2 notes: “It was pretty stressful at times, but it really teaches you responsibility and just having to take on things and having to get people to work, in your groups you know just being a leader.” Student 2 clearly indicated a sense of personal growth through the project which is inherently a worthwhile endeavor. Of every student, Student 2 also most clearly noted a sense of self-accomplishment and self-efficacy to the

extent of recommending service-learning as a regular classroom practice: “I recommend it because it really pushes people to step out of their comfort zone and it helps you to realize what you can do as just a teenager in your high school.” As with the other two themes, the comments related to seeing mathematics as worthwhile indicate an affective response of students beyond simply what they gained cognitively from the course.

In addition to the three major themes related to developing a productive disposition, another theme emerged from the data: relationship building. This major theme of relationship building is a bit more interesting in that the questions didn’t necessarily prompt this type of response as they had on the concept of engagement. Student 1 discussed the importance of bringing emotion into the project (empathy for the victims) as well as the significance of face-to-face contact and “actually” talking to people. This was verified by Student 2 who spoke of the importance of learning how to relate emotionally with the people that they surveyed. The relationships that developed were more than just between the students and the subjects of their study, but also between the students themselves in building an atmosphere of teamwork and also between the student and the teacher. The importance of teamwork and the involvement of all students were emphasized throughout the interviews. The organization of the service-learning project into a group or team based project seemed to be vitally important for the students’ positive experience of the project. Teacher vulnerability and humility throughout the project was also a contributing factor the students’ positive experience. Often hurdles or unforeseen problems in the project were discussed (though prompted by the interviewer) but the students seemed to indicate that they were able to handle those hurdles through the help of other students or conversing with the teacher in a more relaxed manner than in

the formal setting of a classroom. The teacher was almost seen as co-involved student since the outcome of the project was uncertain. On relationship building the interviews with Student 5 and Student 6 were particularly revealing. Student 5 mentioned six different times the importance of building relationships with different kinds of people in order to make the project a success. Student 6 spoke about the project being fun and enjoying the time spent with Student 5 (with whom Student 6 was good friends) and a Student cameraman who aided in the project that Student 6 wouldn't normally hang out with. Student 6 also talks at length about the story of a particular wild fire victim and how hearing that story affected them. Student 7 also noted how the project gave some insight as to how the victims were actually affected, more so than could be gleaned off the news coverage of the fire. This theme of relationship building speaks to the formative nature of education in general and service-learning specifically. Many of the issues raised by students tie into affective components of math education mentioned in the theoretical framework. This particular theme was surprising and more will need to be done in the full study to determine how this fits with the conceptual framework of developing a productive disposition.

### *Implications*

It is clear from the transcripts that the students often wanted to discuss the specifics of the project (statistics, wild fires, survey process, etc.) and the interviewer was looking for a more general statement on service-learning (several times clarifying “can you speak to your experience, not of this project specifically, but in a general sense...”) – hence the rewording and re-asking of questions to obtain that desired response. In developing future interview questions it is noteworthy that students tended to not be able

to separate the specifics of their project with service-learning as a general teaching strategy (perhaps since this was their lone experience of it). Questions in the actual study took this into account and were phrased in such a way as to glean general insights on service-learning while still addressing the specific student experience of their project. The unexpected theme of relationship building indicated that in designing a successful service-learning project (and thereby having a richer experience from which to gain insight through student interviews and observations) the relational component that is expected of students needed to be taken into serious account. It was clearly a valuable experience for students to learn how to operate as a team and also learn how to relate to the subjects of their study. Also, the complete study should take into account student perspectives both before and after the project experience to note any changes in perspective.

Finally, the full study gathers data over a longer period of time (from the beginning of the year to the end). While the student interviews included in the pilot study were revealing, those interviews alone don't speak to one of the key components of this study: examining how a change of habit contributes to forming/cultivating mathematical affections. By definition a longer amount of time needs to be examined before any comment can reasonably be made in regards to the students' habits.

## **CHAPTER IV: RESULTS: INTRODUCTION & QUANTITATIVE DATA**

### **Introduction**

The overall goal of this study was to describe the development of affect in students within the context of a mathematics classroom as students engage in a service-learning project. This affective development was analyzed through the above theoretical framework with a particular emphasis on examining the impact of regular guided reflective practices on student valuation of mathematics. The study answers the following research questions:

1. To what extent does service-learning impact the cultivation of mathematical affections among students?
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?

The nature of the affective domain of learning lends itself naturally to being examined through qualitative methods. This particular study was not intended to quantify affect in students but rather to offer a description as to how affect forms in students as they engage in service-learning. The descriptive nature of this study made a qualitative approach more appropriate, however some quantitative data was gathered as well.

Each research question was addressed through the following sources of data and measurement (Table 5):

Table 5: Summary of Research Questions and Methods of Measurement

Research Question	Variable	Indicators	Measurement
1. To what extent does service-learning impact the cultivation of mathematical affections among students?	Development of Productive Disposition tied directly to involvement in community experience	<ul style="list-style-type: none"> <li>• Role of community experience in learning</li> <li>• Role of community experience in engagement</li> <li>• Changes in perspective on course content</li> </ul>	Interviews Surveys Reflection Journals
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?	Understanding course content (Sensible)	<ul style="list-style-type: none"> <li>• Role of community experience in understanding course content</li> <li>• Perceived relevance of community experience to course content</li> </ul>	Interviews Surveys Reflection Journals Observed interactions with students and instructor
	Applying course content (Useful)	<ul style="list-style-type: none"> <li>• Role of community experience in applying course content</li> <li>• Recognition of practical application of course content</li> </ul>	Interviews Surveys Reflection Journals Observed interactions with community partner
	Valuing course content (Worthwhile)	<ul style="list-style-type: none"> <li>• Role of community experience in producing a rewarding sense of work committed to course content</li> <li>• Recognition of community experience to sufficiently important to justify effort spent</li> </ul>	Interviews Surveys Reflection Journals
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?	Cost/Benefit analysis on the feasibility of implementing community experience	<ul style="list-style-type: none"> <li>• Recommendation to utilize community experience in other courses</li> <li>• Valuing time spent on community experience over against traditional methods of learning</li> <li>• Drawbacks of community experience</li> </ul>	Interviews Surveys

The results of this study will be described by separating the quantitative measures from the qualitative. The quantitative data that was gathered from the FSMAS survey will

be discussed first including the shortcomings that were discovered in measuring affect through purely quantitative measures. This will be followed by an overview presentation of instances of observed affect in the case study students as they participated in class work days throughout the course of the project. While the observations are primarily intended to reinforce what was collected from students in their reflection journals or in their interviews, it is still worth considering quantitatively the instances of engaged versus non-engaged affect that occurred during the course of the project. Finally, the results of community based learning student survey (Appendix F) will be presented.

After presenting the quantitative results, the qualitative results will be presented. This will first be done by presenting a narrative on the impact of the service-learning project on each of the five members of the case study. After examining each case, the connection between each narrative and the conceptual framework of a productive disposition will be detailed, with a concentration on the experience of mathematics as “sensible,” “useful,” and “worthwhile.” Additional themes that emerged in the coding of the data will also be presented; this includes a discussion of mathematics as a relational discipline and also common responses that can be characterized in terms of current research on growth mindset (Dweck, 2006) and grit (Duckworth, 2016). While both growth mindset and grit are current in educational research, each will be tied into the overarching theme of this study, mathematical affections, and the affective domain in general. Finally, a summary will be presented of the results as they pertain to each research question with a particular emphasis on bringing to light how the results pertain to research question three, the feasibility of implementing service-learning as a practical means of achieving affective learning objectives.

## Quantitative Data

### *Fennema-Sherman Math Attitude Scale*

For the modified version of the FSMAS students were scored a 1 to 5 scale with higher scores indicating a more positive attitude toward mathematics. 36 students responded to the FSMAS at both the beginning and the end of the school year. A matched-pairs t-test was run measuring the difference in scores (end of year – beginning of year). The change in FSMAS scores was not statistically significant ( $t = -.037, p = .515$ ). Below is a summary of the FSMAS scores at the beginning of the year, the FSMAS scores at the end of the year, and a chart of the paired differences, end of year minus beginning of year.

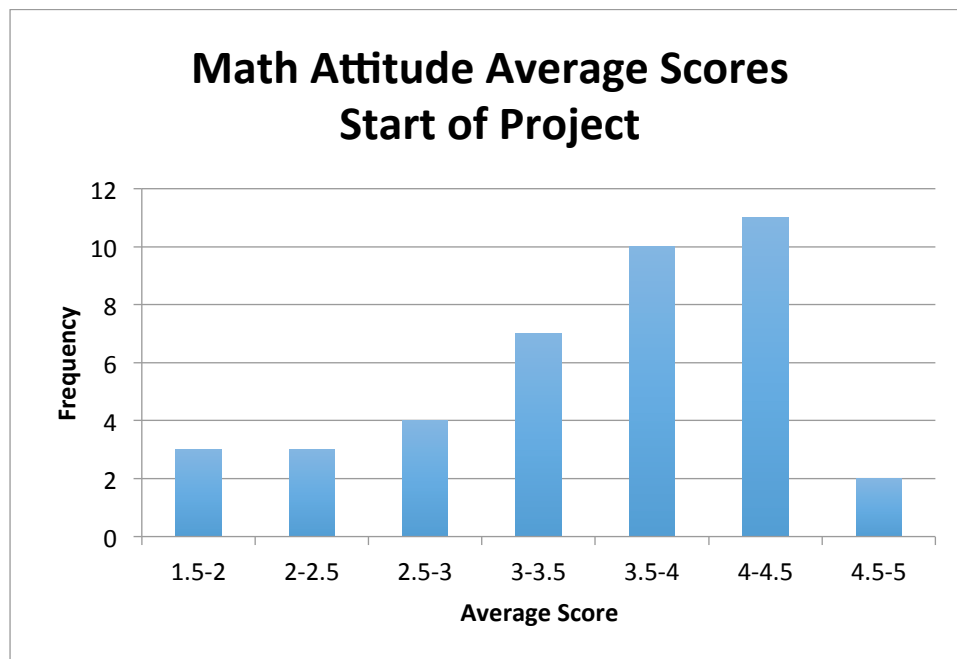


Figure 3: Average FSMAS Scores at Start of the Project



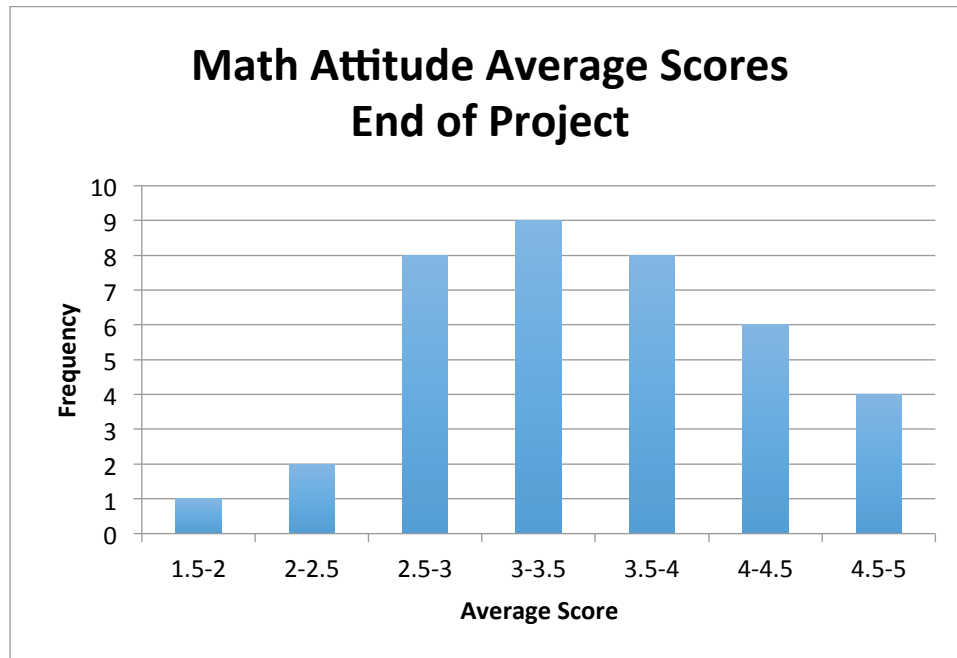


Figure 4: Average FSMAS Scores at End of the Project

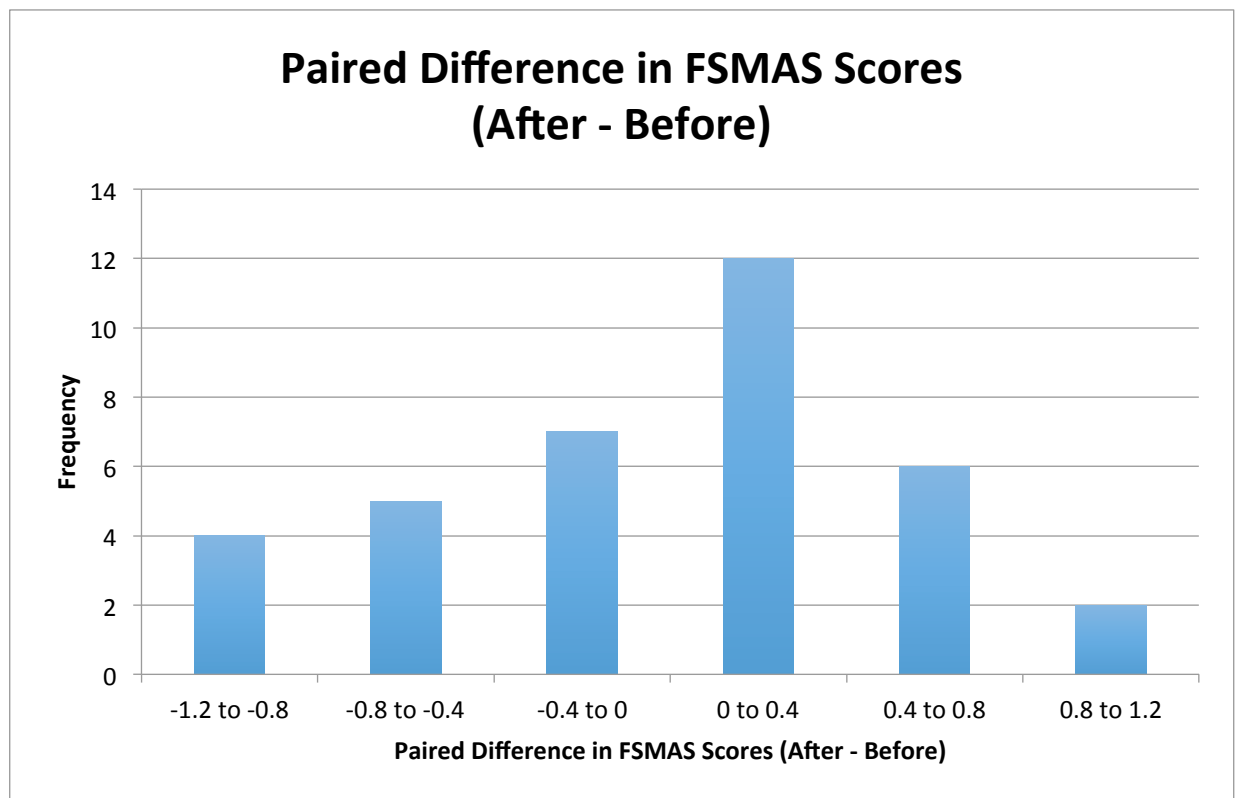


Figure 5: Paired Differences in FSMAS Scores (After – Before)

Ultimately the service-learning project over the course of the school year failed to produce any statistically significant change in the FSMAS scores. A two-sided matched pairs t-test produced a p-value of 0.97. There is no evidence of a change in FSMAS scores in either the positive or the negative direction. If any trend is to be noticed, it seems to be a trend toward the middle – toward a more neutral position. At the end of the year, lower scores became higher and higher scores became lower. For all of the students who reported a decrease in FSMAS scores at the end of the year, the average score from the beginning of the year was a 3.8125. For all of the students who reported an increase in FSMAS scores at the end of the year, the average score from the beginning of the year was a 3.2125. Sixteen students reported a decrease in FSMAS scores and 20 reported an increase. For those reporting a decrease, the average decrease was -0.5234. For those reporting an increase, the average increase was 0.4125. The scatterplot below illustrates the general trend of higher starting FSMAS scores reporting a decrease while lower starting FSMAS scores report an increase. A linear regression t-test on the data, testing if  $\beta$  and  $\rho$  are both less than 0, produces a p-value of 0.003. This indicates a significant negative correlation between starting FSMAS scores and change in FSMAS scores.

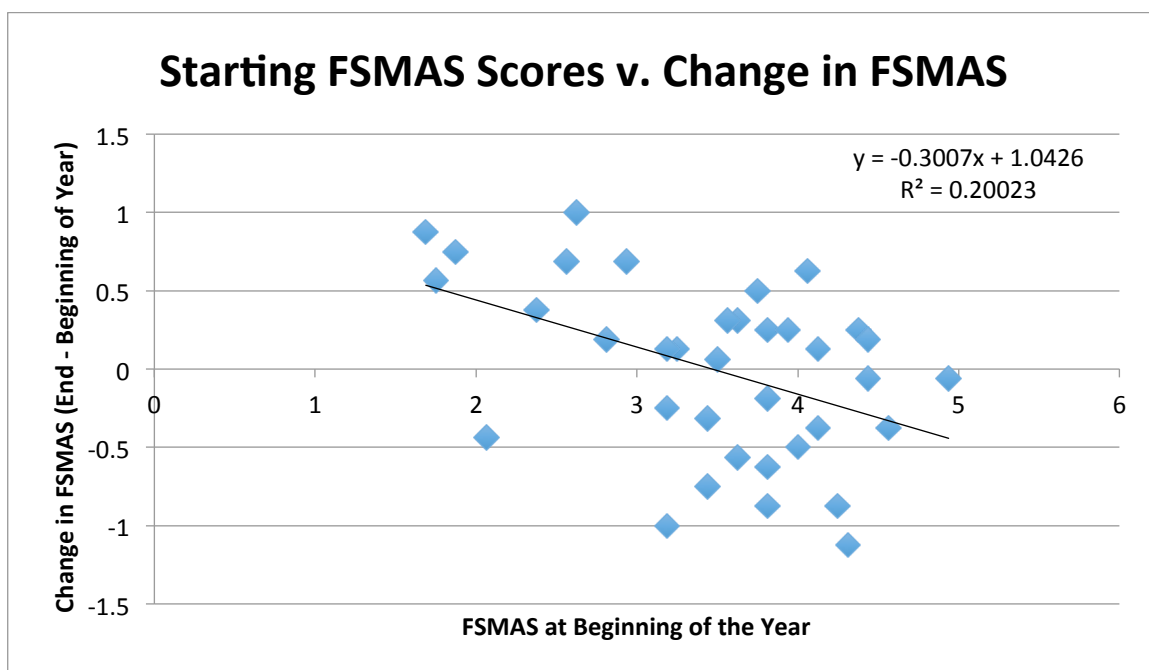


Figure 6: Starting FSMAS Score v. Change in FSMAS Score

First, it should be noted how significant it is that the students who reported the lowest FSMAS scores, the ones who had the most negative attitude toward mathematics, reported positive changes in their attitude towards mathematics at the end of the service-project. The specific questions that received the strongest responses (either positive or negative) are also worth noting. As described above, the FSMAS contained questions worded in both a positive and negative fashion. At the beginning of the year the positively worded question that received the lowest average score was A2 – “It wouldn’t bother me at all to take more math courses”. At the end of the year, this question was no longer the lowest average score. This indicates that where once students would in fact be bothered to take more math courses, that is now less the case. At the beginning of the year the negatively worded question that received the lowest average score was U10 – “Taking mathematics is a waste of time”, scored 1.9 on average. In other words, students started the year with a recognition that mathematics is in fact *not* a waste of time. At the

end of the year this questions remained the lowest scoring negatively worded question, now scored at 1.74, the lowest score received by any question either at the beginning or end of the year. It seems to be clear that this particular group of students understood mathematics to be worthy of their time. At the beginning of the year the highest scoring positively worded question was C3 – “I am sure that I can learn mathematics”, scoring a 3.98. At the end of the year, the highest scoring positively worded question was now U4 – “mathematics is a necessary and worthwhile subject”, scoring a 4.16, the highest scoring of any question at either the beginning or end of the year. At the beginning of the year, this question scored a 3.83 on average.

It is significant to note in the context of this study, developing mathematical affections (developing the habitual inclination to see mathematics as worthwhile) that at the end of the service-project the highest scoring question on the FSMAS survey related to mathematics being a necessary and worthwhile subject. In fact, when examining the pointed question U4 – mathematics is a worthwhile and necessary subject, there was a statistically significant change in student responses. A paired t-test on student responses to this specific question, testing if there was an increase in the average response, produced a t-value of 2.097 and a p-value of 0.022, making this positive change significant at the 5% significance level. Another statistically significant change occurred in the FSMAS question related to the usefulness of mathematics, U6 – “I will use mathematics in many ways as an adult”. While there are other questions on the FSMAS survey that pertain to the usefulness of mathematics, such as U2 – “I study mathematics because I know how useful it is”, these questions tend to incorporate the usefulness of mathematics with some other motivational component; asking students to identify if the

usefulness of mathematics is the reason why they study it now. Question U6 simply asks students if they recognize the many uses and applications of mathematics to their lives after school, even for those who won't be going in STEM careers. A paired t-test on student responses to this specific question, testing if there was an increase in the average response, produced a t-value of 2.255 and a p-value of 0.015, making this positive change significant at the 5% significance level. It is interesting to note that statistically significant changes occurred in the two FSMAS question that most directly tie to the description of a productive disposition; seeing mathematics as useful and worthwhile.

Table 6 below summarizes the highest and lowest single questions averages on the FSMAS survey at both the beginning and end of the year for both positively and negatively worded statements.

Table 6: Highest and Lowest Single Question Averages on FSMAS Survey

Beginning of year responses			
Average Score	MIN/ MAX	Wording	
2.95	MIN	+	A2+ It wouldn't bother me at all to take more math courses
3.98	MAX	+	C3+ I am sure that I can learn mathematics
1.90	MIN	-	U10- Taking mathematics is a waste of time
2.88	MAX	-	E11- I would rather have someone give me the solution to a difficult math problem than have to work it out for myself
End of year responses			
2.82	MIN	+	E2+ Mathematics is enjoyable and stimulating to me
4.16	MAX	+	U4+ Mathematics is a worthwhile and necessary subject
1.74	MIN	-	U10- Taking mathematics is a waste of time
2.95	MAX	-	E12- I do as little work in math as possible

Returning to the overall results of the FSMAS survey, why would students who reported higher FSMAS scores at the beginning of the year have a tendency to report lower scores at the end of the year? What about engaging in a service-learning project produces a decline in the students' attitude towards mathematics? There are several facets that I believe are important to consider. First, there appeared to be some considerable

confusion in the wording of some of the FSMAS questions that resulted in students offering responses that they did not mean to give. This will be explored in greater detail below. Second, the timing of the end of year FSMAS could be leading to these results. Many of the students were seniors in high school and the end of year FSMAS was being given at the end of their high school career. While not true of every student, a good number of students confessed a great deal of apathy towards the whole process of schooling – they were ready to be done with high school and off to college. This will also be explored in greater detail below but it can perhaps be summarized by viewing these students' responses not so much in terms of a more negative attitude towards mathematics, simply an indifferent one. Finally, as evidenced in the case of Tabitha described in detail below, some students may have reported a decrease in FSMAS scores because their initial positive attitude towards mathematics came from their ability to succeed in classrooms where the normal practice was for teachers to lecture, students to mimic examples, take exams with similar problems, and repeat. The process of being stretched to consider a broader understanding of mathematics was uncomfortable for those students and they reported not enjoying this new approach to mathematics as much on their FSMAS survey.

Students were asked about their FSMAS results in the final interviews and a common topic was mentioning a misunderstanding of the survey questions. Sample student comments include:

Ava: I don't know why I would've said 'very untrue' in the fall. I think I must've accidentally clicked that one... That's weird that I put that in the fall.

...

Interviewer: Okay, then last one, “I expect to have little use for math when I get out of school,” in the spring you said 1, ‘very untrue’ and in the fall ... I’m sorry in the fall ‘very untrue’ and in the spring ‘very true.’

John: Okay (laughs) on this one I mislabeled it.

Interviewer: Okay, that's what I thought, but that's why I mark it and that's why I ask. So how would you score it?

John: I’d probably scored it a two now.

...

Interviewer: ... looking at some of these, number 10: “I do as little work in math as possible” was a 2, where you said ‘somewhat untrue,’ and now at the end of the year it's a 4, where you say ‘somewhat true.’

Charlotte: I think I meant the opposite way.

Interviewer: You meant the opposite way?

Charlotte: Like now I do more work, so that would have been a 2, and then before it should have been a 4. Does that make sense?

Interviewer: You feel like you do more work now than you did before?

Charlotte: Yes.

Interviewer: Okay.

Charlotte: It should be a 2 now, not 4.

Interviewer: Okay.

Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun.

The last comment was included to indicate the significance of students misunderstanding FSMAS questions or marking their intended responses incorrectly. Charlotte wanted to communicate the benefits of the service-learning project and felt that the FSMAS survey did not in fact capture that response. Confusion on some of the questions – or an admission that they were careless in recording their responses to the survey – occurred in 3 out of 5 in the case study and 7 out of 10 students interviewed. These comments in the interview phrase lead to suspecting the results of the FSMAS quantitative analysis to be misleading as an overall measure of change in student affect. To be clear though, the statistically significant results that were determined for the individual questions U6 and U4 should still be considered noteworthy since no student commented on any confusion on these questions in the interview phrase and both questions were worded in a straightforward and positive manner.

In addition to confusion over some of the FSMAS questions, another reason to doubt the validity of the survey is that it might be capturing the students' attitudes typified by the end of a school year rather than their attitudes specifically toward mathematics. For instance, when it was pointed out to John, a high scoring FSMAS



student at the beginning of the year, that his end of the year FSMAS had dropped (became more negative) he offered this reasoning:

John: I wouldn't say it became negative really. I'd say it's maybe a little more indifferent about my math because I'm not sure if I take it as seriously as I did before. It's not like I hate math or anything but it's still a four which is higher on the scale, correct? So I'd still say I value math highly but I don't take it as seriously as I used to, if that makes sense. At the end of the year it's kind of like I've coasted toward the end of the year, so that might have an effect on what my survey responses were

John is a high achieving student who elsewhere communicated the benefits he saw in the service-learning project and valuable applications of mathematics he hopes to draw upon as he studies mathematics in college. I record his response here to offer some potential insight as to why some of the high scoring FSMAS responses saw a decrease at the end of the year. Student comments like this and their comments on confusion with the FSMAS survey also potentially raise the question of how valid a quantitative measure of affect can actually be, even when analyzing *traits* (Goldin, 2014). For the purposes of this case study however, the benefit of the FSMAS survey was to give a starting point for discussion in student interviews and reflection journal prompts.

### *Observations*

Below is a summary of the observed instances of engaged affect in the case study students as they participated in class work days throughout the course of the project. While the observations are primarily intended to reinforce what was collected from

students in their reflection journals or in their interviews, it is still worth considering quantitatively the instances of engaged versus non-engaged affect that occurred during the course of the project. Official observations occurred at seven different times across a span of four months during the spring semester of the project. All of the observations except for one instance occurred in the context of my classroom. The one exception was the field observations made when the students took a field trip to the property of the partner organization in order to deliver their surveys. All of the remaining six observations that occurred in my classroom actually occurred twice; once for each of the two sections of AP Statistics that I taught. Of the six observations occurring in the classroom, five were on days that students were given time to work in groups on different phases of the project. The remaining classroom observation occurred when a guest speaker was invited to come speak to the students on homelessness and interacting with the homeless. In all classroom cases, I was able to situate myself at a raised table to the side of the classroom that gave me an unobstructed view of the five students in each section that were the focus of observations. On the field trip to administer their survey I was able to follow behind the students as they took a tour of the property and then delivered their surveys. Observations occurred over twenty minute time intervals during which I would rotate my focus to each of the ten students in the study, with only five of them being present in any one section of the course. This process would allow me to note about 80-100 observations during a given day (40-50 per class period), resulting in 8-10 focused observations of each student in the study on a given observation day.

Based on the work of Schorr and Goldin (2008) in researching student affect in a math classroom, I decided to focus my observations on the student cues that could lead a

noticing teacher to infer the affective engagement of the student. As seen in the attached field notes (Appendix D), I organized my observations into two major categories: engaged affect inferred and non-engaged affect inferred. The tabular format of the observations serves to provide a visual snapshot of the classroom as it is clear to see whether more engagement or non-engagement was observed. Under each of those two main headings were four specific observations: facial cues, physical gestures, verbal interaction with other students, and verbal interaction with the teacher. I chose to focus on these four types of observations because, to a noticing teacher, these observations would be the easiest way to infer student engagement. The discussion that follows is organized according to each of these observation types.

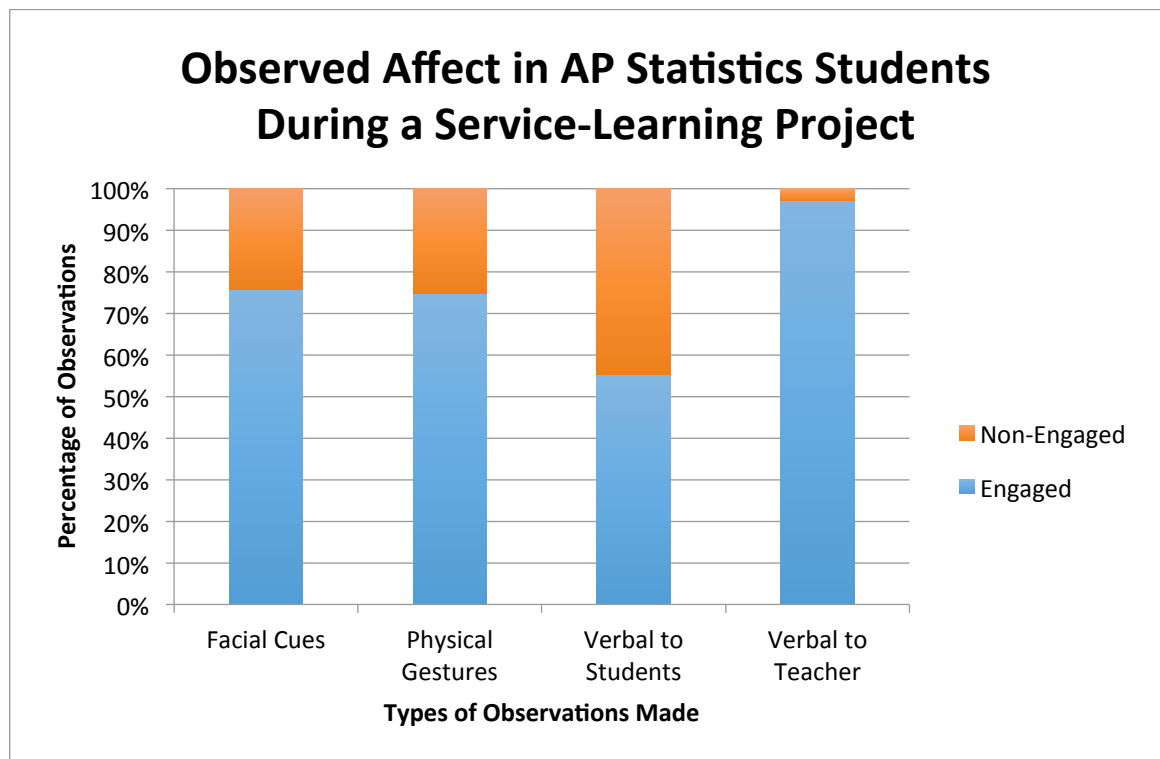


Figure 7: Summary of Observed Inferred Affect

For this group of students their facial cues overwhelming tended toward demonstrating engagement. The most noted facial cues of engagement (or non-

engagement) was eye contact to a speaker (be it a guest speaker or another student) and focused attention to written or typed work. This group of students as a whole generally maintained appropriate eye contact. If the guest speaker was speaking, eyes were on the speaker. If a student across the room asked a question or interacted with the teacher, eyes turned to that student. If students were tasked with group work (such as doing data analysis from their survey or typing a summary report) then eyes were generally focused on their work. Non-engaged facial cues occurred when the students would noticeably break eye contact and temporarily “zone out” (stare at the wall, ceiling, window, etc. in stark contrast to where the eyes of the other group members were focused). This “zone out” observation was noticed much less in comparison to observations of engaged facial cues and none of these could be said to have occurred for an extended period of time. While it is certainly possible that the students remained engaged listening despite not looking, since I am left to infer engagement and this “zone out” was a noticeable change in facial cues from the normal attentiveness of eye contact it was marked as an observation of non-engagement.

Engaged physical gestures, much like facial cues, occurred in approximately a 3:1 ratio with non-engaged physical gestures. Engaged physical gestures included posture (sitting up straight, leaning forward to focus on work on the computer or paper), pointing at the screen of their computer or paper as if to be following a line of reasoning, typing at their computer or their calculator, taking notes from a guest speaker, and raising a hand to either ask a question of the guest speaker or simply to indicate their engagement in the conversation (for instance when the guest speaker asked how many students had interacted with homeless people before and students raised their hands to indicate that

they had). The highest number of engaged observations fell into this category. Non-engaged physical gestures would include a student leaning back in their chair (typically in combination with the non-engaged facial cue of staring off), laying their head down, fidgeting with their nails or a water bottle or some other object. These observations come with the same qualification as the non-engaged facial cues – none of them occurred for an extended duration and despite these observations a student could very well have still been engaged mentally. A final item of note in this category was noting on the field trip the times in which students would get out their cell phones – this was the most observed trait of non-engaged physical gestures and it only occurred during one day of observations (since students are not allowed to have their phones out during the typical school day).

Verbal interaction with other students was about a 50/50 split between being categorized as engaged or non-engaged. This was most likely due to the observations occurring while students worked together in small groups. This atmosphere accounted for a lot of engaged interaction, with students asking clarifying questions of each other as they worked together to complete a task. At the same time, it wasn't difficult for students to occasionally get off task and have conversations with other students that didn't pertain to their work on the service-learning project. However, during the day of the guest speaker when students were not working in small groups but sitting as a class and listening to a speaker, there were zero recorded observations of non-engaged verbal discussion with other students. A recurring observation in engagement in this category was students clarifying statements or questions from class with each other. This group of students seemed to regularly engage in the practice of checking for understanding amongst each other rather than always asking questions of the teacher. If the teacher

made a statement or asked a question that one student in the group was not sure of, they would regularly ask the student next to them for clarification and at least some member of the group would be able to explain the concept. It was not always the same member asking the questions of the group nor was it always the same member answering the questions. The group demonstrated a mutual support of one another when it came to understanding the material at hand.

The final category of ‘verbal interaction with the teacher’ was overwhelmingly observed as evidence of engagement amongst students rather than non-engagement. This may be due to the nature of the category – if you are talking to the teacher you are probably engaged in the class. There were only two recorded instances of non-engaged verbal interaction: during a time of students working in groups when a student asked the teacher about their favorite sports team and when a student asked the teacher about their favorite restaurant. Neither of these comments is by any means disruptive and both were brief exchanges, however they did momentarily distract from the content at hand. Despite these examples, as mentioned, this category was overwhelmingly evidence for engagement. There were numerous and consistent observations of students dialoging with the teacher or guest speaker or partner organization – not simply asking one question and getting an answer but engaging in a give-and-take conversation.

In summary, as a whole, the students of this group were clearly engaged in the project work at hand. The main demonstration of engagement was student discourse. This classroom evidenced an environment where students were free (and expected) to engage in conversations both with each other and with the teacher.

### *Community-Based Learning Survey*

The community-based learning survey (CBLS) was administered at the end of the project to every student in the course. The survey was completed by a total of 40 students, including all 10 of the students that were the focus of this study. This survey (Appendix F) asked students to respond to a series of statements on a 1 to 5 scale, with 1 being 'strongly disagree' and 5 being 'strongly agree.' Below is a table summarizing the responses to each statement. Also included for each question is the result of a one sided significance test with  $\mu = 3$  (a neutral position), testing whether the student responses were significantly above or below a neutral response depending on the wording of the question. Questions worded positively were tested to see if the response was above a neutral position. Questions worded negatively were tested to see if the response was below a neutral position. Table 7 below summarizes the results of the survey.

Table 7: Statistical Results of CBSL Survey

1. The community participation aspect of this course helped me to see how the subject matter I learned can be used in everyday life.				
$\bar{x} =$ 4.025	$s =$ 0.83	$t =$ 7.79	$p$ -value (to 3 decimals) 0.000	Significant at $\alpha = .05$ ? Yes
2. The community work I did through this course helped me to better understand the course content.				
3.35	1.08	2.06	0.023	Yes
3. I feel I would have learned more from this course if more time was spent in the classroom instead of doing community work. (Tested $\mu < 3$ )				
2.675	1.14	-1.80	0.040	Yes
4. The idea of combining work in the community with school coursework should be practiced in more classes.				
3.675	1.12	3.82	0.000	Yes
5. I feel that the community work I did through this course benefited the community.				
3.875	0.82	6.73	0.000	Yes
6. I felt a personal responsibility to meet the needs of the community partner of this course.				
3.35	0.89	2.47	0.009	Yes
7. My interactions with the community partner enhanced my learning in this course.				
3.2	0.88	1.43	0.080	No
8. The community work involved in this course made me more aware of my own biases and prejudices.				
3.375	1.21	1.96	0.029	Yes
9. The work I performed in the community enhanced my ability to communicate in a "real world" setting.				
3.35	1.05	2.10	0.021	Yes
10. The community aspect of this course helped me develop my problem-solving skills. (Tested $\mu \neq 3$ )				
2.975	0.733	-0.22	0.584	No
11. The other students in this class played an important role in my learning. (Tested $\mu \neq 3$ )				
2.825	1.06	-1.04	0.303	No
12. The service aspect of this course helped me develop a deeper appreciation for the course content.				
3.5	1.01	3.12	0.002	Yes



Students responded to the majority of the statements in manner that was significantly different than a neutral position. While there is no before and after survey of the CBLS in the same way there was for the FSMAS, all of the statements in the CBLS are phrased in a way that prompts a response based upon the student experience during the project. In other words, the student responses are best interpreted as “As a result of this project I feel....”

A key takeaway from the result of this survey is to notice the alignment between particular survey questions and the research questions of this overall study. For research question 1 (To what extent does service-learning impact the cultivation of mathematical affections among students?) it is important to note the statistically significant response of students in question 12 of the CBLS. For research question 2 (What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?) it is important to note the statistically significant responses of students to questions 1 (useful), 2 (sensible), and 3 (worthwhile) of the CBLS. Finally, in regards to research question 3 (To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?) it is important to note the statistically significant response of the students to question 4 on the CBLS. While this study was focused on acquiring qualitative data from students through reflection journals and interviews, the results of this quantitative survey do lend support to the qualitative analysis that follows.

## CHAPTER V: RESULTS: QUALITATIVE CASES

### **Introduction**

While the quantitative data is helpful in noticing certain trends and patterns, the full picture is missing if that data were not complemented with a qualitative analysis. The nature of the affective domain of learning lends itself naturally to being examined through qualitative methods. This particular study was not intended to quantify affect in students but rather to offer a description as to how affect forms in students as they engage in service-learning. The descriptive nature of this study makes a qualitative approach more appropriate. Goldin (2014) distinguishes between *traits* that characterize different individuals' typical affective responses in mathematical situations, typically studied quantitatively through surveys, and *states* that refer to affect in the moment when doing mathematics, typically studied qualitatively through interviews. As noted in the definition of *disposition* given above by Gresalfi and Cobb there is both a *trait* and a *state* component to be considered. Also, it is important to note that the purpose of this study is to analyze what impact service-learning has on changing the affective traits of students. Therefore, while the student traits can be assessed by beginning and end of year surveys, to gain a better perspective of *how* those traits change through the affective states students experienced while participating in the service-learning project interviews and student journals were analyzed.

One example of how the quantitative data alone does not give a complete picture can be seen in analyzing the relationship between a student's FSMAS scores and their course average. A linear regression t-test on end of year course averages v. end of year FSMAS scores, testing if  $\beta$  and  $\rho$  are both greater than 0, produces a p-value of 0.000193. This indicates a significant positive correlation between end of year average in

the course and the end of year FSMAS score (the data is shown below with the red points indicating the five students in the case study). It would be easy to look at this data analysis and conclude simply that students with higher grades in the course have a better disposition towards mathematics (or vice versa).

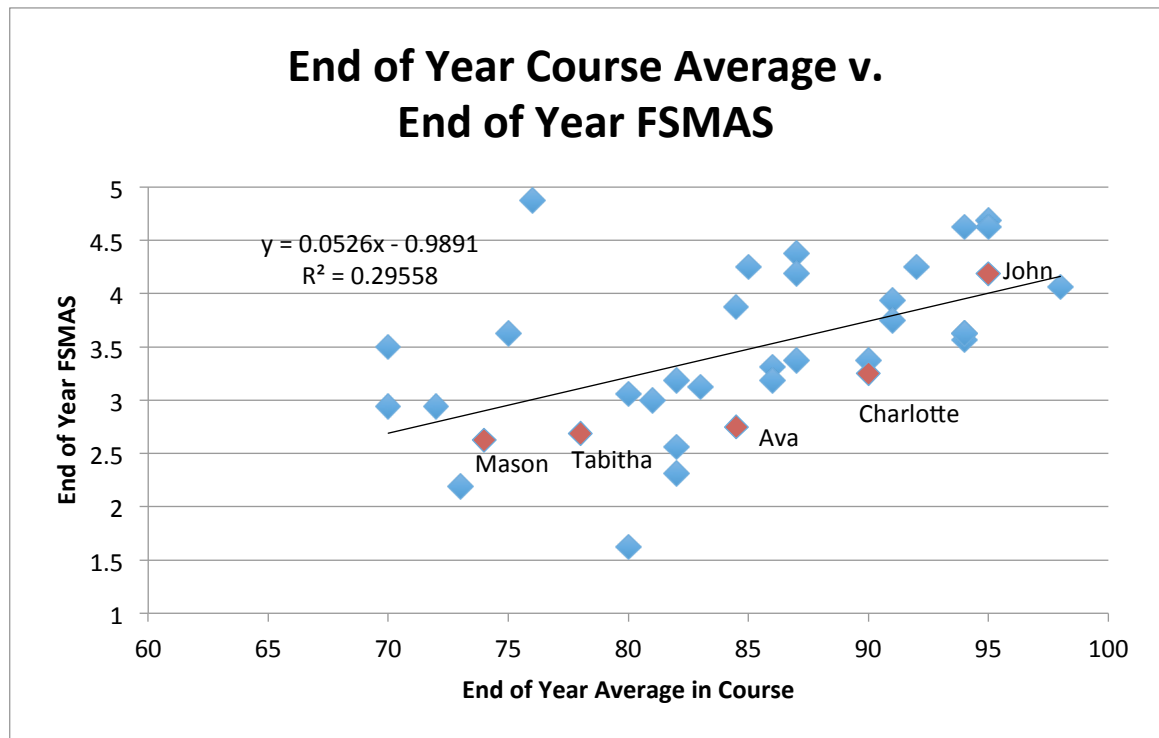


Figure 8: End-of-Year Average v. End-of-Year FSMAS Score

However, a linear regression t-test on end of year course averages v. change in FSMAS scores was also run, testing if  $\beta$  and  $\rho$  are both greater than 0, and produced a p-value of 0.0286. This indicates a significant positive correlation between end of year average in the course and the change in FSMAS score at the 5% significance level, but no longer at the 1% significance level. This graphical display (shown below) becomes noticeably more scattered, and the five students in the case study (indicated in red) that had followed the general trend in the previous graph (with lower grade averages having lower FSMAS scores), are now scattered in various directions. In other words, a student with a low

course average and low FSMAS score still had a relatively large positive change in their FSMAS scores after completing the service-learning project. These varying changes in student responses are worth exploring in greater detail rather than having simply a quantitative measure and leaving it at that.

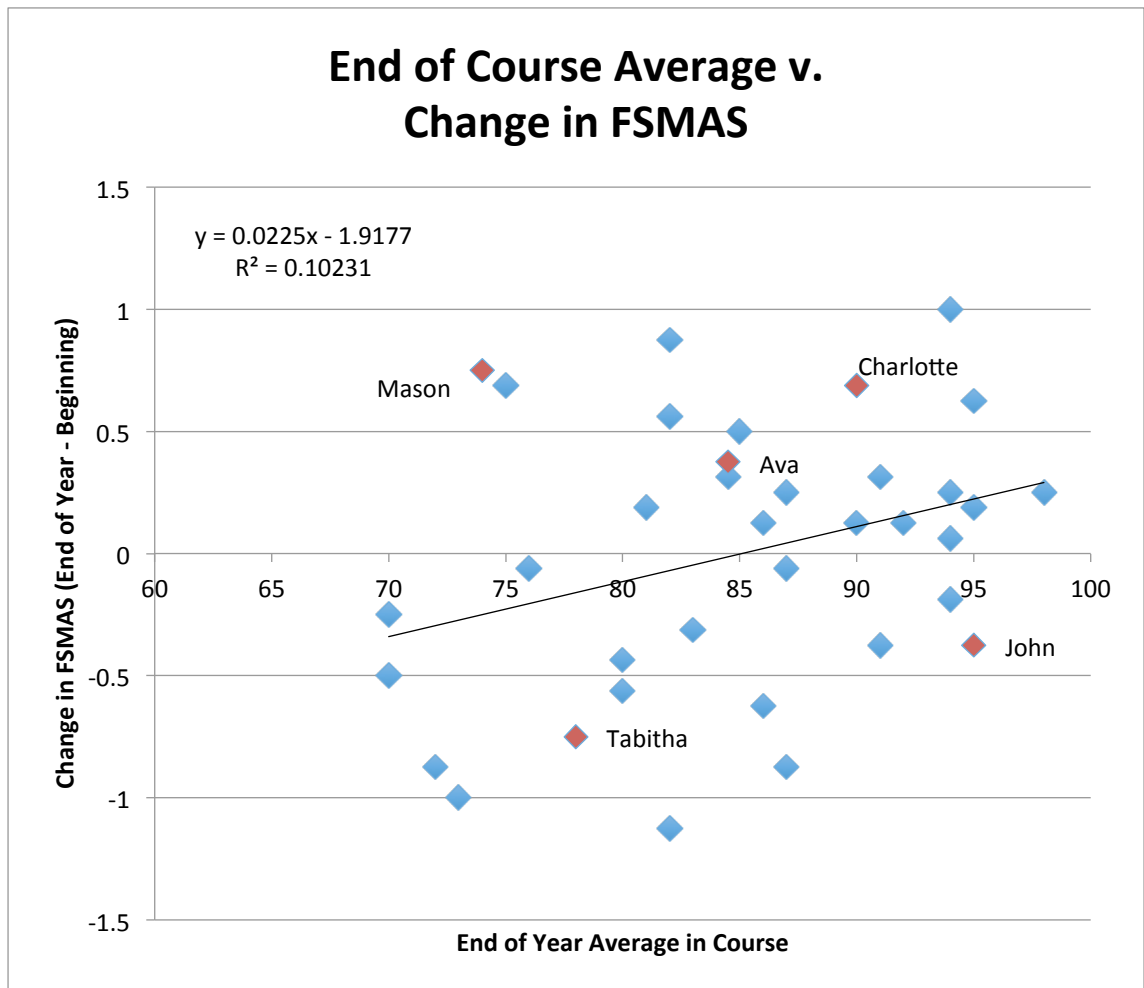


Figure 9: End-of-Year Average v. Change in FSMAS Score

### Tabitha

Tabitha is a senior female in section A of my AP Statistics course. She was classified as a low-achieving student, defined as having a course average under 85. Her FSMAS score at the beginning of the year fell in the middle third of all responses with a

3.4375. Tabitha was also classified as a student that I had not previously taught in a service-learning project.

From the beginning of the project, during the initial interview, Tabitha showed indications of understanding mathematics classes to be a passive experience where the teacher teaches, the students take notes, and then repeat similar problems on exams. This picture became clearer as the year progressed, but even at the beginning Tabitha used phrasing similar to students in the pilot study where the modifier “actually” was used often; implying that if in this project the students were “actually” learning or applying what they learned, then they wouldn’t have been if the class proceeded without the project. When asked about her initial impressions of the project in the beginning of the year interview, Tabitha noted:

Tabitha: I think the practical purpose of this experiment is to learn how to use math practically. Use it to actually help someone in real life and learn how to fix situations or improve situations using statistics.... I kind of liked that it is over a long period of time and we have to read articles about it and actually learn what we are doing.

Even though Tabitha’s prior experience (or understanding) of math class was for it to be a passive experience, she didn’t view this in an entirely negative light. As noted in her journal entry when asked why anyone should value his or her math education:

Tabitha: I think that we should value our math education just because it is an integrated part of our everyday life. I also think most of life will require some sort of basis in math, so in that sense we should value

it just because it is necessary for our success. Some people will value it more than others based off of what their natural gifts are, I am not mathematically inclined so I would gander [sic] to say that I do not value my math education as much as I should, but even then I do still see it's value and significance in everyday life. I mean in my own life even working at my summer jobs I have to use a lot of basic math, so practically it's a valuable skill.

Tabitha didn't consider herself "a math person" and admitted that she probably doesn't value her math education as much as she should but still valued math for its practicality, even basing it on her own life experience through her job. Tabitha (as well as Ava who will be discussed below) presents an important example of what it means to cultivate an appreciation of mathematic; that this cultivation doesn't mean coming to love mathematics or consider yourself more "mathematically inclined," but rather to value mathematics for larger reasons beyond one's on competence in the discipline. Tabitha demonstrates how ones perception of mathematics can be shaped over time by environmental factors such as schooling, family, and work that go beyond the content being taught. However, I contend that while Tabitha expressed an appreciation for the practicality of math, the focus on practicality did not offer her a well-rounded view of mathematics which ultimately led to some of her struggles during the project. When students were asked to conjecture in their initial journal entry how a stats project might apply to a homeless outreach organization, Tabitha had difficulty:

Tabitha:       Honestly, I'm not sure about what this project could be I really do not know how much statistics could apply to [the partner

organization]. I think it may have something to do with the percent of homelessness in certain areas and predicting how homeless and low income people will be affected by the influx of people moving to [the city]. Or perhaps seeing how many people are helped by [the partner organization] and when and where they are most effective.

As the year and project progressed, Tabitha began to develop a more complete picture of what it looks like to apply mathematics outside of the classroom in a service context.

Tabitha: As the semester has progressed I have slowly understood more and more about what we are doing in this project. Honestly, at the beginning I really didn't like it, but I think the group work and the articles helped get us invested in the project. It is also fun to mix school work with community work. And even though I struggle with statistics I think it is helpful to see the practical use of math in real life situations, even if they are some what [sic] simulated. One of my favorite parts of the project has been reading the different articles specifically the news articles. It's exciting to see how what we are doing applies to current events. Also, the article about statistics, though humorous, was a struggle to read through. I actually really understand the correlation between the project and what we are learning in class probably more than I understand what you normally teach in class, if I'm being honest.

While Tabitha began to expand her view of how math could be applied outside of the classroom, and connected well? the service component of the project, she still experienced a disconnect between the applied math of the project and the passive math classroom that she was used to being a part of. When asked at the end of the year on how the project went:

Tabitha: I think it went well. I really liked being able to help the community and I loved the idea of mixing a service project with what we were doing in the classroom. However, I think I did not completely understand what we were doing in the class so though I loved being able to serve I do not think it necessarily helped me understand the concepts that we were being tested over.

This disconnect between the project and the classroom-as-usual approach seemed to introduce some discomfort into Tabitha's initial understanding and valuation of mathematics. For instance at the beginning of the year Tabitha noted:

Tabitha: I do not want to pursue math but if I have to take a math course in college I will.

This is in keeping with her own self-identification as someone not mathematically inclined but who still values learning more mathematics – if necessary for a practical purpose. Whereas at the end of the year Tabitha noted:

Tabitha: I think one new thing that I didn't feel about math at the beginning of the year is a certain level of uneasiness about math. I just don't feel comfortable with it. It is not one of my natural gifts and stats



has helped me realize that I hope I do not have to take math courses in college.

Note the change in tone from Tabitha being comfortable with taking more math courses in college (not voluntarily, but if necessary) to now expressly mentioning that she hopes to not have to take more math courses. It is important to note that Tabitha attributes this change to the non-traditional approach to learning that occurred in her statistics class.

Tabitha was forced to confront her misconceptions of what it means to apply mathematics outside of the classroom. So, while Tabitha reported a decline on the FSMAS survey, it can be argued that her initial responses should not be interpreted as positively as they were, and thus her decline in scores at the end of the year not as significant of a change. Gomez-Chacon and Haines (2008) offer examples of a positive attitude toward a false perception of math being classified as a negative attitude. In other words, seeing math positively because the student views it as a set of procedures to be memorized and they feel capable enough of doing that, could legitimately be understood as a negative attitude toward mathematics. If Tabitha's responses are viewed in this light, then it can be argued that her FSMAS responses were not really indicating an increasingly negative attitude, but rather simply revealing by the end of the year the negative attitude that existed at the beginning but that was unrealized by the student.

A further explanation of Tabitha's increased uneasiness about mathematics that rose from the service-learning project can be found in her end of year interview. When asked to give an overview of the project Tabitha noted:

Tabitha: It was like taking like the stuff we learned and then creating the problems from that, I don't know it was just really hard for me.

Because like we're used to doing problems but like it's pretty much set up and then like taking that extra step. It was hard for my brain.

Tabitha is clearly indicating what she is used to in math class and how that experience contrasts with her experience of the service-learning project. While it can be argued that this is a beneficial change and struggle for Tabitha to go through, it is important for teachers who are considering implementing service-learning projects to consider the impact of the project on students like Tabitha. The number one thing that was a struggle for Tabitha was trying to fully mesh her previous understanding of the math classroom with the applications she was forced to make in the service project, thus leaving her feeling as if she was really doing two things at once: class and the project, without any intersection.

Tabitha: I really like service-learning projects but I think one of the things that made it confusing was so we would do like the service work and like the journal entries and the proposals while we were still learning other statistic stuff. My brain like it just works like you learn one thing and then you learn something else, but we were trying to like mesh it but they didn't feel like super connected, it felt like we were learning about two separate things but at the same time.

Despite this personal feeling, Tabitha still found value in the service aspect of the project and recommended that it be continued for future classes.

Tabitha: I would recommend that they do so because it's a really cool concept and I think like the more it gets done and the more practice

that you have doing it, the better it will become and like they'll be able to refine the techniques so the parts that were confusing you can like work them out. I think learning to practically apply what your learning in the classroom is important.

In summary, Tabitha felt comfortable in the math classroom that she was used to – one predicated on students simply being asked to work problems similar to those modeled by their teacher in class. While Tabitha didn't enjoy this or believe she was particularly strong at it, she nonetheless found value in it because she had been instilled with the idea that math is practical. However, when the actual application of math didn't match with her experience of the classroom, her attitude toward math shifted. When asked at the end of the year to clarify why she thought her responses to the FSMAS shifted, Tabitha offered this insightful commentary:

Tabitha: Yeah, I think because we've never had to practically apply it before and because it's like a completely new concept for us. I think I just really, it made me uneasy to know that like, I couldn't, like that that was extremely difficult for me to know that like I can learn concepts in the classroom but when it comes to practically applying it, I was kind of, not able. Like maybe if we had been like doing service projects like from freshman year to now, then I would be like more comfortable with it and I would like be able to think outside the box of what we're taught but, yeah.

Tabitha concludes by submitting the notion that her response would be different had she been engaged in this method of learning from earlier on in her schooling. Tabitha is a

prime example of noticing the long-term impact of the manner in which mathematics is taught (the liturgies of the classroom) on a students' perception of the value of mathematics and their ability to apply it. In a moment of great self-awareness, Tabitha notes that if she had been engaged in projects like this before, her ability to “think outside the box” of what she had been taught (in other words, to creatively problem solve) and to feel comfortable in applying math to real-life would have been improved. This presents another key reason why the FSMAS alone does not present a complete picture of the impact of service-learning on the affections of students. I believe all teachers would count it as a positive for their students to creatively problem solve and to feel comfortable in applying mathematics to real life. The fact that Tabitha realizes this importance as well should be seen as a positive take-away from the service-learning project, and her negative response as arising from the uncomfortable feeling of realizing her schooling had not prepared her to do this.

### **Ava**

Ava is a senior female in section A of my AP Statistics course. She was classified as a high-achieving student, defined as having a course average above 85. Her FSMAS score at the beginning of the year fell in the lower third of all responses with a 2.375. Ava was also classified as a student that I had previously taught in a service-learning project when she was a freshman in geometry.

Ava shares many characteristics in common with Tabitha in her perception of her math education – not seeing herself as a “math person” but at the same time understanding that math has practical applications and should be valued. While Ava holds this in common with Tabitha, one key difference to note is that Ava had been a part

of a service-learning project during her freshmen year in geometry whereas Tabitha had not.

In the initial interview at the beginning of the year Ava painted a clear picture of her current perception of her mathematical abilities:

Ava: Well, I've just never been a "math person," I guess. Literally, ever since second grade, every single year, math has been my worst class and the class I've had to work the hardest in just to make a decent grade in comparison to the rest of my grades. Even though I know math is important and I definitely am glad that I've taken it, it's always been my hardest class and I don't enjoy math.

Interviewer: Okay. I'm curious and, you may or may not have an answer, but why second grade?

Ava: Well, in second grade at the public school that I went to, they had this thing called compacted math. Basically you took one test and it determined whether or not you were going to be in the upper track or the lower track. I made the minimal grade to go into the upper track, so they just put me in that, and you had to learn two years of math in one. Ever since that, ever since I started on the upper track, it was just ... I struggled a lot. I hated my teacher in second grade, so ever since then.

Like Tabitha, Ava indicates that she knows math is important but at the same time does not have a positive view of her own abilities, even going further than Tabitha did by

tracing those feelings back to a very specific moment in her schooling. When asked to expand upon why she was still glad to have taken math even though she did not enjoy it:

Ava: Because obviously math is important for so many different things. Different careers, and even just getting into college is important. Even though I don't enjoy it and I'm not good at it, I know that it's important and I know that it's necessary and I'm glad that I've taken it.

Like Tabitha, Ava's perception of the value of a mathematics education relies on it being practically applicable to life after school, or even just to get into college. While Ava started the project at a similar place to Tabitha in terms of their perception of mathematics, Ava came into this project with prior experience in service-learning, giving her a better idea of what might transpire over the course of the year. When asked to reflect on how she felt after the project had been introduced:

Ava: I definitely thought it was interesting when the presenters came and talked to us about it. I was really glad that they were bringing in a side that wasn't just like, we're just measuring statistics. They brought in the side that was also like, this is a service project as well, and I like that it's had both sides of that... I definitely think [service-learning projects] are awesome. From geometry, I don't remember every single theorem that we learned at all, but I definitely remember doing that project for [the partner organization]... I think it [service-learning] definitely is more effective for getting a general point across.

While Ava had a very negative attitude towards her experience of mathematics at the beginning of the year, she had many positive things to say about her prior experience with service-learning in mathematics and her excitement at being able to do that again in statistics. In her journal reflections during the year Ava reiterated her perception on the value of mathematics and of service-learning.

Ava: I have never been particularly good at math or found it particularly enjoyable, however I recognize that learning math is an important part of becoming an educated person, no matter what field of study you choose to pursue.... I value my math education because I know that having a solid base of math is important for nearly any career choice (and for just generally functioning as a person in 2016). Also, I value the liberal arts goal of educating the whole person. Even though math is not my strongest subject, taking math is valuable because it makes me a more well rounded person.

Here Ava expands on her valuing of mathematics; while she doesn't particularly enjoy it, she views it as being necessary for anyone to be considered an educated person. This again points to something beyond the curriculum being taught as having an impact on shaping how a student does or does not appreciate mathematics as a discipline. In this case, Ava points to her own schooling (particularly her experience at a school that emphasizes the need to be educated in multiple areas).

Ava: "Mathematics is a worthwhile and necessary subject"-- I still agree with this statement. I think I really value the [education I received at this school]/general liberal arts education goal of educating the

whole person and having a strong core curriculum in all disciplines. So, even though I'm not very good at math nor do I enjoy it much, I recognize that it is important and that I wouldn't ever be a well educated person without taking math. With that said, I don't plan to use math in my college major or in my career, so maybe I really just agree with this statement on the principle of becoming a well educated person someday.

Ava reveals that while it has been instilled in her to value her mathematics education, it is more of an assent that she has been trained to give versus having a deeper, meaningful appreciation for the discipline. Ava offers some insight as to how service-learning could offer a tangible example of developing a true appreciation for mathematics. When asked to reflect in her journal if service-learning had an impact on her understanding of statistics:

Ava: Yes, because I applied [statistics] to a real life situation.... I feel that I now understand better how stats can be used in real life. This is a useful take-away. I would recommend this project for future classes.

When asked in her end-of-year interview on the value of having service-learning projects in mathematics:

Ava: I definitely like the idea of having a service project that goes with what you're learning I think when you can apply what you're learning in that type of way. It just makes it more real world kind of.... I think the most rewarding thing was to be able to see the



presentation that [classmates] did and with the [partner organization] people there was cool to see the results to be presented to them and they can actually use this.... I think [service-learning is] good because it does allow you to get some real world perspective and at the same time it's not just something that's a useless real world perspective, like you are getting that perspective and you're also contributing something to people who can use that to do something good with it.... This project has meaning and it has a clear use, so we're not just going out and measuring something random.

In these responses, Ava seems to be indicating that service-learning has offered a very practical way to value what she is doing in mathematics classes, versus her previously stated assent to valuing math just because it is an ideal that she is expected to value. Ava clearly mentions finding value in the service aspect of the project, but she also indicated how the regular practices (liturgies) of the classroom that changed in order to implement the project were equally impactful on her appreciation of the project:

Ava: Well we definitely talked more in this math class than another other math class about reading assignments and having a journal entry due every week, like reinforced while we were learning about the tests that we were going to be using the journal entries were requiring you to think beyond that and think about homelessness and think about the specific facets of [the partner

organization] that maybe we wouldn't be talking about in a regular stats class.

While Ava certainly gave indications of service-learning, and the changing habits of the classroom that resulted from instituting the service-learning project, as impacting her appreciation of mathematics, she also indicated that it ultimately was not enough to overcome her preconceived notions of mathematics. When presented with her FSMAS scores that indicated a positive change towards mathematics:

Ava: Honestly, I don't know if my attitude towards math has changed positively or just changed a little bit, just maybe more towards the type of math that I don't dislike as much, but I'm just never going to be a person that enjoys math.

Interviewer: Okay.

Ava: I just never have been that, I never will be.

Interviewer: Okay. Why do you say that?

Ava: I don't know why people are ... Some people are born just better at some things and other people are born better at other things I guess. I've just always been more of a person that's better at humanities and that likes that more. I think I wrote this in my journal entry. I find myself having to do a lot more work in math and science classes to get grades that would disappoint me if I got them in humanities classes and then not enjoying the work that I have to do as much as I enjoy doing humanities work

Interviewer: Okay, fair enough. The last thing is what you said in your journal entry of saying what you said about working harder but not enjoying it as much, but then at the same time recognizing that, to be considered an educated person you have to have math, and so seeing value in that. I was wondering if you can expand on that last line in your journal entry of agreeing with that statement on principal, of math being worthwhile.

Ava: Yeah. I think it's just been drilled into me through [this school], because [this school] focuses so much on having a strong core curriculum and saying you need to understand all disciplines to be a well educated person even if you don't like this one subject and even if you don't want to do that in college or in your career, it's still important that you understand it at least at a basic level. I think I've come to value that and understand why that is an important thing.

Ava seems to lump service-learning in mathematics as a “type of math I don’t dislike as much.” While Ava has certainly indicated finding value in service-learning and describe more positively than her previous experience of math courses, her experience over the course of one school year was not enough to completely overcome the culmination of her experiences in prior math classes. Despite not enjoying math and believing herself to not be as good at math as other disciplines, Ava reiterates multiple times the value of math still being engrained in her from her schooling. This once again speaks to the formative nature of education and the values that are instilled in students. Perhaps had Ava been

more exposed to the “types of math she doesn’t dislike as much” her outlook on her own ability in mathematics would be very different. Much in the same way as Tabitha, it seems Ava had been drilled to give intellectual assent to the notion of mathematics being worthwhile (which is more than most students have) but at the same time because the manner of mathematics presented to her was very rigid and she had very fixed ideas of math being valued for its practicality, she still had a very negative view of her own ability to thrive in a mathematical context. While she indicated signs of that changing slightly in the service-learning project, it certainly did not change fully.

### **John**

John is a junior male in section B of my AP Statistics course. He was classified as a high-achieving student, defined as having a course average above 85. His FSMAS score at the beginning of the year fell in the upper third of all responses with a 4.5625. John was also classified as a student that I had previously taught in a service-learning project when he was a freshman in geometry.

Unlike Ava and Tabitha, John began the year with a positive view of mathematics. Through the course of the project John’s view seems to have solidified but his understanding of what mathematics is and how it can be applied in service changed. John indicated his excitement and piqued interest in the project, specifically tying that interest to the service component of the project, during his initial interview:

John:           A project without service, it would be fine, but I feel like it wouldn’t be as fulfilling because we get to work with these homeless people and see what they’re like. Yeah, I would say that I would feel more fulfilled by the service project, I don’t know,

because we're actually benefiting people. It's not like a contract or anything, and it's not just a piece of paper kind of project.... I'm also happy and fulfilled because I feel like we're benefiting [the partner organization] as an organization. I feel like I'm not doing it because I have to do it for school, but I'm doing it because this would be a cool service project to do or something like that.

Early on in his reflection journal, John mentions his excitement about the project in reference to remembering his experience in doing a service-learning project in geometry. John, like Ava, looks back positively on prior service-learning experiences in mathematics.

John: I remember the gazebo problem in geometry and that was extremely fun and it seemed like we were actually benefiting the [partner organization] community even though we were only high school freshman.

John ties this prior experience to finding value in the service-learning project in statistics, understanding the project to be meaningful and worthwhile because of the impact of the results:

John: It is exciting to anticipate the results of our survey and use data that could actually make a difference in someone's life rather than just be a problem on a piece of paper.

In his response, John makes use of the word "actually" that was noted in Tabitha's response earlier. The use of "actually" when applied to the difference making potential of

this project implies that doing statistics in some other manner than service-learning would not be as applicable or meaningful.

While John certainly ascribed meaningfulness to the service aspect of the project, he also maintained a high view of mathematics in general, even seeing himself majoring in mathematics in college.

John: Math is an important part of our curriculum because it teaches us skills in life that we will use later in life. Just the other day I used math to find out that the premium gas ends up being cheaper for my car than the regular gas because of the better gas mileage. I also see myself majoring in math for college. Statistics seems applicable in everyday life and although I might not be constructing surveys and calculating statistics, I will be more aware of them and understand what they mean when I come across them in life. Math is helpful in so many ways and is seen in everyday life beyond the classroom

While John clearly states seeing the beneficial applications of mathematics, and also his appreciation of the service component of this project, a major change that he underwent during the year was coming to see how these two things might integrate together; how service could be an integral part of the math classroom. In one journal entry the students were asked to reflect on the meaning of the word ministerium (a Latin word that translates as ‘ministry’ or ‘service’). Ministerium is one of the four core values of the school and a concept that students are inundated with on a daily basis. One of the goals of the project was to see if students came to associate that term with the project that they

were undertaking in their math class, or if they still saw service as an action that takes place outside of the classroom.

John: I would still define a ministerium as when a group comes together to selflessly benefit others. However, my view has somewhat changed on what this looks like. Usually when you think of [service] you think of doing labor intensive work to assist someone who is less fortunate than you. For this project we didn't do any manual labor, but still helped the people at [the partner organization] and the previously homeless people themselves. These people got a chance to talk to someone face to face and express their feelings, which brightened their day (at least for my person it did). So the definition remains similar to what I had previously, but this project changed my perspective on how ministerium is able to manifest itself.

By the end of the project John came to the point of being able to see how service can be integrated in the work being done in the math classroom.

John also discussed in his reflection journal how the project impacted his understanding of the material that was being learned in class. He attributes to the project instilling in him the motivation to stick with what he admits are tedious calculations. This certainly indicates John seeing math as worthwhile (worth the time and effort spent) but it can also interesting be seen as contributing to the development of grit, a critical skill needed to be successful in mathematics (Duckworth, 2016).

John: Analyzing the data has proved to be somewhat challenging. It was difficult at first because I felt like I was overwhelmed with information about all of these different questions. I also didn't really remember how to do some of the tests and it was frustrating when you didn't find one that was statistically significant. However, once I calmed down it wasn't really too difficult to actually do the calculations. It just took a decent amount of time to type out all the steps and show my work with different data displays.... I enjoyed coming up with the conclusions at the end that actually made sense and benefitted [the partner organization]. It was cool to see the fruits of our labor come to so many different conclusions. At the same time, performing these tests ended up being painstakingly long and tedious. However, it was worth it to me in the end because we finally reached many conclusions from the data we collected and actually contributed to a great organization by coming up with real answers in a real-life situation.

John noted that the tedious work was "worth it in the end" because of the benefit of the project to aiding the needs of the partner organization. This is a primary example of indicating the worthwhileness of mathematics that students can find while engaging in service-learning.



During the end-of-year interview, John again recalled his prior experience with service-learning in mathematics when discussing the impact of this project on his learning:

John: Just doing the project and the gazebo project, from freshman year, definitely aided my learning. I feel like I going to remember how to do some of this statistical stuff and I feel like I'm definitely going to remember how to do this project, like what we did during this project because of [the partner organization].

When asked if he would call the project a success:

John: I would. I would call it a success because I learned new things about myself and my situation and I got to see a different side of life through all the homeless people living at [the partner organization]. I got see this incredible community, and I'd call it a success because of all the results that we had as well. I feel like regardless our entire class just learned new things about themselves and about the value of community as a whole.

Here John attributes the project in being helpful for him and his classmates to be able to have moments of introspection; to learn things not only about mathematics but also about themselves. This is key piece of evidence for the benefits of service-learning and the impact that moments of guided reflection can have upon students. While this particular quote is not describing a deeper appreciation of the discipline of mathematics, I believe it is important to recall the pervading negative math attitudes discussed at the beginning of this paper. The goal of introducing service-learning into mathematics is to move students

away from those feelings of stress, frustration, and fear that they feel towards mathematics. One would think that if a student were to have the personal experience of learning something deeply about themselves, as described above by John, that the student would not harbor such negative feelings towards the class that brought that experience about.

A final note from John on the importance of community interaction in the learning experience:

John: I could write [stats] on my paper all I want but I don't know what it actually looks like in the real world. I feel like doing it for the community makes it even more special because it makes you feel good inside that you did something for someone else and your helping these people that are less fortunate than you obviously. I feel like the interactive side of it is very important, and is needed as opposed to just staying in the classroom and just learning the material.

Before moving on from John, it is important to note that his beginning of the year FSMAS score was 4.526 and his FSMAS score at the end of the year was 4.1875. Despite nothing but positive statements about the mathematics service-learning project, according to the FSMAS numbers John's attitude towards mathematics became more negative. To me this is another indication of a flaw in analyzing only the quantitative FSMAS data. For students with high FSMAS scores to begin the year it is difficult to maintain those high scores by the end of the year, not because of anything to do with what happened in the math classroom but because of the general change in student attitudes between the

start of a school year and the end of one. When asked if John would agree that his attitude towards mathematics has become more negative:

John: I wouldn't say it became negative really. I'd say it's maybe a little more indifferent about my math because I'm not sure if I take it as seriously as I did before. It's not like I hate math or anything but it's still a four which is higher on the scale, correct? So I'd still say I value math highly but I don't take it as seriously as I used to, if that makes sense. At the end of the year it's kind of like I've coasted toward the end of the year, so that might have an effect on what my survey responses were.

### **Charlotte**

Charlotte is a senior female in section B of my AP Statistics course. She was classified as a high-achieving student, defined as having a course average above 85. Her FSMAS score at the beginning of the year fell in the lower third of all responses with a 2.5625. Charlotte was also classified as a student that I had previously taught in a service-learning project when she was a freshman in geometry.

Charlotte is an interesting case to study because she displayed one of the most significant increases in FSMAS scores by the end of the project. Also, while she is classified as a high achieving student, I had taught Charlotte previously in geometry during her freshmen year and Charlotte barely passed that course. Charlotte would be the first to say that the success she experiences in mathematics comes more from her work ethic and diligence to complete homework and ask questions than it does from an innate gifting in mathematics, a discipline she would openly admit that she did not enjoy.

During her initial interview, Charlotte indicated why she harbored very negative feelings towards mathematics:

Charlotte: [Math] makes me feel uncomfortable, restless, irritable, impatient because unlike literature or history you can't just write out your thoughts or whatever. Math is like, certain numbers and certain things. There's a right or wrong answer. If you don't get the right answer then it's like, oh, you get everything wrong basically. There is some partial credit, but ... Math problems seem to be more confusing to me because there's intricate little steps that you have to do. It makes me feel restless because the math problems that we're doing are way more complicated than 2 plus 2. You have to go through all of the things and work a long time on the problems. It takes time. I feel like you have to have like, a mathematical brain to understand a lot of math things.

Charlotte clearly indicates holding a very fixed mindset approach to mathematics (Dweck, 2006). She also sees mathematics as either right or wrong with no room for any individual expression or creative thought. She has become so used to this experience of mathematics that she finds it confusing when she is asked to attempt some type of creative problem solving application.

Charlotte: It's not confusing when someone teaches it or when it's on my notes, it's confusing when I actually have to apply it.

Again the modifier “actually” is used by Charlotte to indicate that an application of the material is outside of her normative experience of mathematics. Despite Charlotte’s

expression on the confusing nature of applying mathematics, she indicate an early excitement about the service-learning project:

Charlotte: I was really excited to do [the service-learning project] because it was more of like, a hands on project.... I like how this project we're able to actually make a difference and serve someone instead of doing it for our own benefit. I was excited. I think the experience has been really good.... Then, we were able to actually meet the owners [of the partner organization]. They were actually able to come in our class, so we had a firsthand experience of what it was about. I think the community service part of it really gives a hands on experience. For us, we go to a Christian school and we're all about serving others. I think that goes with like, our school. It helps us better understand that we can use our math in something that's not necessarily math-related, like community service.

So despite expressing many negative feelings towards math and confusion at applying it, the service-learning project really opened Charlotte to a new possibility of how mathematics can be used and how worthwhile it is. As Charlotte progress through the year in her reflection journal she clearly articulated the worthwhileness of the project she was undertaking. To be clear, this does not mean that she all of a sudden fell in love with math and enjoyed it, but rather even though it may not have been enjoyable she viewed the work as being worth the effort:

Charlotte: I am so excited to go out and give the survey. I hope it goes smoothly because it can be extremely useful to [the partner

organization]. I'm excited to go out there and give a real survey to the people. I know it will be rewarding when the whole project is done. I'm dreading writing all the papers but I know it will be useful in the long run.

One of the keys to Charlotte's change in perspective on mathematics over the course of the project may be her general understanding of the importance of mathematics and education. Much along the same lines as Tabitha and Ava, Charlotte mentions a certain value of education being instilled in her through the course of her education. Again this speaks to the formative power that education has on student values apart from the content that is being portrayed in the classroom. When asked why she should value her math education:

Charlotte: I should value my math education because it will be important to me later in life. I may not see a use for it now but I know the basic understanding of math will help me solve problems later on. My teachers have poured so much knowledge into me and I know it all has a purpose. I should value it because God calls us to use our knowledge for His glory. I am being given this knowledge, therefore I shall use it in some way to glorify Him.

While Charlotte has very positive things to say about understanding the importance of her math education, much like Ava she gives little indication at the beginning of the year of this being anything more than an intellectual assent – knowing that math is useful because that is what she has been told versus making the reality more personal to her educational experience.

A transition starts to happen in Charlotte's responses the more she engaged personally with both guest speakers and the formerly homeless residents that were a part of the study.

Charlotte: We need to treat [the homeless] like they have a story and a name.... I think I learned that everyone has a story and everyone's story matters.... It's humbling to hear someone else's story.

Charlotte clearly speaks to the empathy she develops and this then opens doors for her to begin to see possible applications of mathematics in a brand new light. When asked the same question on why she should value her math education later in the year:

Charlotte: I think we should value everything about our math education. I think it can be extremely helpful in everyday uses. I think my opinion has changed because I've grown to see math in a new and different way. There are several different types of math which can be useful in different areas of our lives. Although I'm not super interested in math I think we should all value it to some degree.

Again it is important to not that the goal is not for Charlotte to now find math her favorite class, which she clearly doesn't when mentioning "I'm not super interested in math," but rather to simply have a deeper and more personal appreciation for the discipline. Above, Charlotte mentions seeing math in "new and different ways." She expands on this when asked to describe her understanding of ministerium:

Charlotte: I think my view on this hasn't changed. Ministerium is serving someone other than yourself. Yet, I did not expect math and

ministerium to go together. This math survey is a ministerium project and I think that it is awesome that they go together.

Elsewhere, after doing the data analysis for the project, the students were asked if they could explain the connection between the service work that they did and the content of the class.

Charlotte: Yes for sure. It is easy to apply these problems to real life situations because that is what they are for! It is exciting to see how they connect.

Students were also asked if analyzing the results of the service project helped solidify concepts from the course.

Charlotte: Yes and No. Yes because it helped with applying it to real life problems but no because it did not eliminate the number of problems and the complexity and specificity of each one.

It is important to note that Charlotte didn't now find the math easier or simpler, but she was able to understand the math at a new level because of how she applied it in a service context. When asked if she would recommend for other math classes to participate in service-learning projects:

Charlotte: Yes I would recommend doing it for other classes! It was neat to see how the things we learned in class played out in the real world. It was a lot of work, but it was all worth it in the end.... I was able to learn more about the [statistical inference] tests through the project and was able to understand them better by applying it to



real life.... I enjoyed helping out the community with our math skills that we had learned in class.

Ultimately at the end of the year Charlotte had many positive things not just about the project but about mathematics in general that were in stark contrast to some of the negative feelings she expressed at the beginning of the year.

Charlotte: “Mathematics is of no relevance to my life.” I do not believe that is true. This project has helped me understand that math can be useful in a lot of ways, they just might not all be obvious. Math will always have relevance in my life because math is everywhere and in everything.... This year I have worked harder in math than I ever have. I have really tried to put effort into my grades and try my best. I used to do as little work as possible but now I realize that math is very important and requires a lot more effort than I have ever put into it. It’s important to put time and energy in math because you will get the best results if you do.... This project has helped me realize that math can be very useful as an adult. So many magazines and newspapers use statistics and now I have the knowledge to know if the data is statistically significant or not. Even though my job might not directly relate to math, it will still come up in every day problems and situations.... I still think math is very valuable even more so after the project is over. I also think ministerium is a way for us to serve the community with gifts and talents. Now, I know I can serve the community with mathematics!

That is something I would have never thought of until this year....

I have had a more positive attitude on math thanks to our awesome survey project!

While Charlotte is reiterating the usefulness of math that she expressed as an intellectual assent earlier in the year, she now has clearly personalized that experience.

Charlotte expressed this personalized understanding of the application of mathematics during her end-of-the year interview as well.

Charlotte: The most exciting part of it was seeing that all of our hard work had paid off and that all of the notes that we had taken in class and everything that we learned this year was able to be applied to something other than math, in a math class.... I think because before I just saw math as numbers in a classroom, and taking notes and equations, but now I can see math in every day activities and uses, so I think when I'm an adult, whether I'm reading the newspaper, looking at a magazine article, I can be like oh, they gave stats and I know stats.

The benefit of applying the material outside of class played a significant role in the growth of Charlotte's appreciation of mathematics. Beyond just the real-life application, Charlotte also ties this appreciation directly to the service-learning aspect of the project.

Charlotte: I think service-learning is an awesome opportunity to learn more about math, because you're actually going out and doing stuff, and it's always helps for me and my brain to actually apply it to something, and to go out of the classroom and go to like [the

partner organization], and I think it's very good.... Because I think it just helps children better understand what they're learning, because I know in the classroom, anything changing it up outside of the classroom is helpful, and it helps the children make a connection between service and learning, that those two aren't completely separate, but that they can actually be used together.

From the service-learning project Charlotte indicates how her perspective on mathematics has changed at the end of the year. She specifies that through the year she did more work in mathematics.

Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun.

She also makes a very clear recognition on her own part to realize the changes in her responses over the course of the year.

Charlotte: Before, my answers are kind of the same, but thinking math is a waste of time, because before, once again, I just thought that math didn't really apply to anything besides math classes, because I never thought I'd be using sine and cosine in the real world or any of geometry in the real world, but now, through our service project and through the geometry project of creating a little tent thing for

the RVs [referencing a geometry project in which students designed shade awnings for RVs], I realized that math can be used in more ways than I thought. They can be used in the real world and not just in a classroom.

And finally, Charlotte not only recognized the change in her attitude by the end of the year but she also explicitly attributes that change to the service-learning project. When asked to comment on the significant increase in her FSMAS score, and if she would verify that her math attitude did in fact become more positive:

Charlotte: Yes, I do feel like my attitude in math has become more positive because ... I really think it's because of the service-learning project and because ... Math is easier to understand when it's used outside of the classroom, and it's more relatable to me when I'm using it in real life situations, so I think just this realization that I can use math in every day activities helps me see it more positively because then I realize it's more useful, and it actually does matter.

### **Mason**

Mason is a senior male in section A of my AP Statistics course. He was classified as a low-achieving student, defined as having a course average below 85. His FSMAS score at the beginning of the year fell in the lower third of all responses with a 1.875. Mason was also classified as a student that I had not previously taught in a service-learning project. Mason, though starting with a very low score on the FSMAS survey, had one of the greatest increases in FSMAS scores by the end of the year. This change was made even more significant in that Mason did not express the general consent to the

usefulness of mathematics made by students like Charlotte and Ava. In this sense, the service-learning project didn't just make the usefulness of mathematics personal to Mason, but it actually introduced him to mathematics being useful in a meaningful and worthwhile way.

Mason began the year in his initial interview with an interesting perspective on the rather algorithmic (and therefore uninteresting) nature of mathematics.

Interviewer: In the journal entry you mentioned... that you're a humanities kid and enjoy working on stuff that requires critical thought and insight. Again, not agreeing, disagreeing, just wanting you to explain your thought process in terms of based on your own experience, or whatever it may be, in terms of why you don't see math as having kind of that critical thought and insight.

Mason: Mm-hmm (affirmative). For me, I see being able to read a chapter in a book and be able to break it down and define character's motives and thought processes and be able to analyze that in the more free thought not so structured. A lot of aptitude things and different tests I've taken, they all said I struggle following multi-step issues. Issues where you start at one place and follow like a set guide of instructions to reach an end. I guess that's a lot of what math is. To me, that doesn't seem like it's incredibly like critical thought based. You can't really provide insight into it. It's just like, this is what you were given and you have to put that in the correct slot where it belongs. There's no ... I guess in theory there's critical

thought and insight in there, but to me it's just you've got to be able to identify that, put it where it needs to go, and then move on to the next step. I don't know why, but that's always been troubling for me to be able to do.

Much like Ava, Mason very specifically describes his perspective of schooling and the impact that it has had on how he approaches his studies. However, unlike Ava, Mason's perspective on his schooling is less idealistic.

Interviewer: One other thing that I just wanted you to again expand on in your own words, in the middle of your journal entry you used the phrase that, "School is just teaching you how to win at the game." I was just wondering if you could explain that?

Mason: Yeah. That was something my dad told me. My dad, to get perspective on that, life is a game that he's playing to win. He's a very, very successful; very, very hardworking person. Very intelligent. Nothing was every given to him. Very, very, very, very, very competitive and a big role model for me. He told me that after freshman year when my grades sucked and I was frustrated and I was upset. He told me, then I made the mistake of saying, "None of this is like ..." for terms of like ... I just felt like, "When am I ever going to use any of what I'm learning right now," specifically about math and science. My humanities grades were fine, but the point is like that's not me. I can succeed in those areas, too. That's not good enough to just be able to do my humanities stuff and be

okay with that. He told me, he said, "That's a cop-out. That's not the point. None of that ... That's not the point of any of this." He said, he was brushing his teeth or he was shaving or something one morning, and he was like, "This entire thing; all of what you do is a game and they're just ..." for college, "They're seeing can this kid learn to adapt and overcome in order to win at the game that he's playing right now, which is high school." That might be true that stuff like imaginary numbers and stuff, like I may never use that, but the grades are a game and that's the score and you've got to score in order to win the game. A lot of it's like, they're not seeing what information do you know, it's can you know the information? Can you understand how to succeed in the environment you're given? That translates a bit. College, so we're taking an investment on this kid, and then that goes on to the business world with like, "So this kids learned how to win in numerous different scenarios. We can take a chance on him, too."

It is worth noting how specific Mason is, even down to the fact that his dad was shaving or brushing his teeth one morning when this conversation took place, and that is why the lengthy quote is included in its entirety. Mason paints a very clear picture of how his dad has impacted his understanding of school as a game that is meant to be played and won with no other point than to make yourself appealing for college applications.

Despite the overwhelmingly negative description Mason had for schooling and his experience of the math classroom, even during his initial interviews he hinted at how his curiosity had been piqued by the introduction of a service-learning project in statistics.

Mason: Yeah, for me [the service-learning project] has made stats a lot more enjoyable; math a lot more enjoyable overall. Knowing that there is like practical application for what we're learning. I really enjoyed that.

Like the previous cases, Mason went on to clarify that it was not just the practical application of the material but specifically the service aspect of that application that impacted him.

Mason: That was really fun to see something that I've traditionally really disliked a lot actually bring me some enjoyment and happiness to see we could use that to really make people's lives better and help get them to a better situation.

Mason closed out his initial interview expanding on his thoughts about service-learning projects and it was clear how the interest in service-learning was grating against the engrained perspective he had of math and school as purely a game.

Mason: Personally, I love [the idea of a service-learning project], especially like I'm not huge on math and not huge on sitting in a classroom at all anyway. I love harknesses [discussion-based learning round a table] and stuff, being able to engage with people and doing things other than just like getting a lecture, so having an awesome thing like a service-learning project, being able to ...



There's something more than just taking a test and like getting a grade. I know it is like, it's a class, it's a game, but like being able to see something that's like, it makes me subconsciously like stats more and want to be invested in it because ... just seeing that there's more to the class than the class itself, especially with [this school]. I like how that works together.

In his journal entries at the beginning of the year, Mason continued this understanding of school being a game and mathematics not being applicable, though he does leave a possible opening for statistics.

Mason: I expect to have little use for math out of High School. Stats is going to be helpful, and same with level 1 algebra, but as for application of the “imaginary numbers”... I’m not entirely convinced. But, maybe I will. Geometry too doesn't seem particularly applicable, but I know school is just teaching you how to win at the game and little of what you learn will be applied after high school.

Like Charlotte, Mason also expressed a fixed mindset (Dweck, 2006) when it comes to mathematics.

Mason: I wonder if I really can learn mathematics. I’ve never really been able to do it well, and that meant I had to work harder than the other kids who were naturally gifted at math. I hang out with a pretty smart group of kids who really seem to do little to no work

in math, and the fact that I still don't "get" stuff gets pretty annoying. Maybe I can learn it, but it will just be really difficult.

Toward the end of the year Mason made the following comment in his reflection journal:

Mason:       The survey work has helped solidify material.... I really appreciated the survey and the project. I think we really can help people. However, I didn't see this so much improve my view of statistics nor my understanding of the course.

This statement seems to be very contradictory. Mason mentions that the survey work helped him solidify the material from class, but then he states that the project didn't improve his understanding of the course. He specifically points out how the project didn't improve his view of statistics that runs counter to statements made in his final interview below. Before examining the end-of-year interview, it is worth pausing for a moment to consider the potential drawback of service-learning that Mason has posed. Mason has very much connected with the idea of service, but at the same time not yet expressed any positive impact of the project on his understanding or appreciation of the material. On the surface this may seem counter to the claims of this study, that involvement in service-learning does impact student appreciation of mathematics. However, it is important to recall the definition of service-learning given by Hadlock (2005). If a project truly is a service-learning project then the service and the content of the course are inseparable; the content is necessary for the service. So then a student saying that they enjoyed or connected with the service aspect of the project but not the content is not truly possible in a well-designed service-learning project. Students without any experience of service-learning in mathematics may see the mathematics and service as disconnected when in

reality they aren't. The goal is to engage students in wrestling with this reality, which Mason clearly demonstrates that he is doing.

Mason: I loved the project. I felt like we could really help a lot of people and.... I think using statistics to do it was a good thing too....  
Yeah, I think I learned a lot more about people through the project than actually using Chi-squared Goodness of Fit test or Tests for Independence. But, I think both things are incredibly valuable.

While Mason's focus is the personal/interactive side of the project, in his end-of-year interview he also still ascribes value to the statistical aspects of the project. He goes on to mention specifically how the statistical components of the project were more difficult for him but at the same time he shows a great deal of determination and grit to succeed in the project (even while still expressing his fixed mindset).

Mason: Obviously, the challenging parts were the stats parts. I had to work pretty hard in stats this year. Nothing against stats, I'm just not very good at it. I just have to dig in when I really want to learn something. I have to spend a lot of time on it. In some ways, I felt like having to use stats to figure out what we learned was frustrating, but I thought it was good too. The benefits were, I was actually seeing, no, this was a real life thing. You're going to use stats in really life. You're going to be able to actually benefit people. You're going to benefit yourself.

What Mason clearly demonstrates is a passion for the project but at the same time the service-learning project has completely shifted his views of mathematics or his ability to

learn mathematics over the course of the year. Mason presents a prime example of service-learning has to offer to students with negative views towards or negative experiences of mathematics: an opportunity to consider a different way in which mathematics might be seen as valuable and worthwhile, and to let that slowly sink in and change their perspectives over time.

The real life service application clearly grabbed Mason's interests. When asked if he would have rather the class done something else with its time besides the service-learning project:

Mason: I think there is so much more to life than just learning and sitting in a classroom and learning. I really liked the going out and doing something with what you've learned. I thought that was great.

When asked about his impressions of service-learning, I could not even finish the question before Mason interjected with an enthusiastically positive response.

Interviewer: The question is, what is your impression of service-learning in general...

Mason: (interrupts) I love it (laughs) I loved it. I love ... Service is awesome. Being able to see the benefits of ... You are actually impacting these people's lives.... We can actually make a difference in our community, and we can use a special set of skills to make math fun. Which for me, math has never been fun. Since I've been a little kid, math has never been fun. It's always been hard for me. It's always been a task for me to sit down and do my math homework. This was actually enjoyable. It was cool to see.

This isn't imaginary numbers. This is real tangible things [sic] that we're doing. It just made it seem a lot more real.

While previously Mason had mentioned in his reflection journal about the project not really impacting his view of math/statistics, here in this answer he makes a clear distinction between how he has felt about math in the past and how he felt differently, in a positive way, about this project. It is very clear that a change is taking place in Mason's understanding of what mathematics can be and why it might be considered worthwhile. To be clear, in his descriptions on the benefits of service-learning Mason goes beyond stating that his enjoyment came from the personal/interactive side of the project, but he also sees value in the statistics itself.

Mason:       Where I thought I saw the stats come in, you could look at the spreadsheet after all the spreadsheets were done, and make charts and graphs and then do the equations on ... Okay, this is what it actually looked like and there was no correlation between money and happiness. I thought that was cool to be able to look at stuff and see, wow, I actually used the stats and statistics skills that I learned this year to hopefully make a difference in our community.

Mason goes so far as to attribute to the project the potential of altering his fixed mindset to more of a growth mindset.

Mason:       I just thought it was a lot of fun and I thought it really changed my view of stats. We started doing this and it really picked up at a time when I was really struggling in it. It really made me think, it's not so bad. I can do this. I can do this.

Perhaps one of the most telling responses that Mason gave was when he was asked to comment on his response in the FSMAS end-of-year survey on studying math for its usefulness. When reading the response below it is important to remember at the beginning of the year how thoroughly Mason had described his understanding of the usefulness of mathematics being purely about showing that you can win at “the game.”

Interviewer: Looking at number 11 [on the FSMAS survey], "I study math because I know how useful it is." In the fall, you said, two, somewhat untrue, and in the spring, a four, somewhat true. I wonder if you could just talk about that.

Mason: I entirely attribute that to stats, just the class itself. It felt a lot more practical and, as well as, with our service-learning project. I saw a lot of real things. Real things were happening there. It really showed me, this isn't some head in the clouds thing if you're not going to be an engineer. I saw a lot of real application to it.

When it was presented to Mason that his FSMAS scores at the end of the year were significantly higher than his scores at the beginning of the year, and if he thought it was accurate to say that his view towards mathematics had become more positive:

Mason: Yeah, definitely, much more positive. It was hard, don't get me wrong and I'm not saying I'm no good at math thing didn't change, but I do think ... I should've changed my ... I am sure that I can learn it, because I am sure I can learn it. It just will take longer and when you don't feel so completely discouraged about it ... When you do feel that you do have shot to understand it and learn it, for

me at least it really raises my attitude towards it. It doesn't feel like it's this hopeless things that I just have to suffer through. It is kind-of just a hill you climb, right?

In the end, the service-learning project seems to have contributed greatly to Mason's increased engagement and interest in mathematics and therefore his own confidence in his ability to succeed in mathematics (even though he isn't going to say that math is now his favorite subject). In this sense Mason is the perfect example of why service-learning should be utilized in more mathematics classrooms. Mason offers what is perhaps the ideal response to strive for in implementing a service-learning project: it is not an over the top in love with math change of attitude, he still maintains several of his initial perspectives about mathematics, but Mason is now very clearly seeing and articulating value in the process of learning mathematics.

### **Summary**

In summarizing all of the above cases, there seems to be clear evidence that service-learning engages students at a deeply affective level and provides a venue for students to wrestle with their valuation of mathematics. At an initial glance, it can be argued that each student in the case study can be said to have increased in his or her productive disposition towards mathematics and each student tied that increase to their involvement in the service-learning project. This specific outcome of developing a productive disposition will now be detailed below.

## **CHAPTER VI: RESULTS: PRODUCTIVE DISPOSITION**

### **Productive Disposition**

Having summarized the year-long experience of the students in the case study and how their productive disposition was cultivated through the service-learning project, I now want to turn and focus on the key indicators of a productive disposition that may not have been included in the student quotes above. The student interviews, field observations, and collected reflection journals were coded following the three major themes of a productive disposition: seeing math as sensible, useful, and worthwhile. These codes initially derived from the definition of a productive disposition offered by the National Research Council (2001), followed in the vein of Jansen (2012), and were confirmed as these themes emerged through an open coding of the pilot study interviews. It is important to note that the purpose of this study is not to argue for what entails a productive disposition and the best way to define and analyze it. Rather, the focus of this study is to examine if service-learning can cultivate a productive disposition as it is currently defined by the National Research Council (2001). That is why the concepts of sensible, useful, and worthwhile were used in seeking to determine if students were developing a productive disposition through the course of the service-learning project. The table below summarizes a basic definition of each term along with synonyms and antonyms. These definitions, synonyms, and antonyms were used in coding when a student was discussing the sensibleness of the mathematics, the usefulness of mathematics, and the worthwhileness of mathematics in either a positive or negative way. While in reality these terms have quite a bit of overlap in their usage (meaning students tend to see one as encompassing or necessarily following from the other) for the purposes



of coding and analyzing the student interviews and reflection journals an attempt was made to treat these terms as distinctly as possible. Table 8 below summarizes the definitions of these key terms as well as synonyms and antonyms that gave an indication that the student was addressing the term.

Table 8: Definition of Key Terms Related to Productive Disposition

Term:	Sensible	Useful	Worthwhile
Definition:	To be reasonable or comprehensible, rational	Being of use or service, serving some purpose; advantageous, helpful; of practical use	Such as to repay one's time, attention, interest, work, trouble, etc.; sufficiently important, rewarding, or valuable to justify time or effort spent
Synonyms:	Logical Rational Sound Sane Well-reasoned	Effective Fruitful Handy Helpful Practical Productive Convenient	Advantageous Beneficial Constructive Good Invaluable Lucrative Profitable Rewarding Valuable
Antonyms:	Foolish Irrational Senseless Unrealistic Unreasonable Unintelligent	Inconvenient Unproductive Useless	Unhelpful Disadvantageous Unprofitable Worthless Bad Harmful Hurtful Injurious

### *Sensible*

The working definition of being sensible is “to be reasonable or comprehensible, rational.” The main idea for this term is that it implies mathematics is understandable, that the service-learning project has in some way aided the student in making intellectual sense of the mathematics involved. The figure below shows the responses of students to a question on the end-of-the semester Community-Based Learning student survey that

pertains to this topic. While the quantitative response is helpful to see that a majority of students would say their understanding of the course was improved through the service-learning project, what follows is a summary of this notion in the words of the students in the case study.

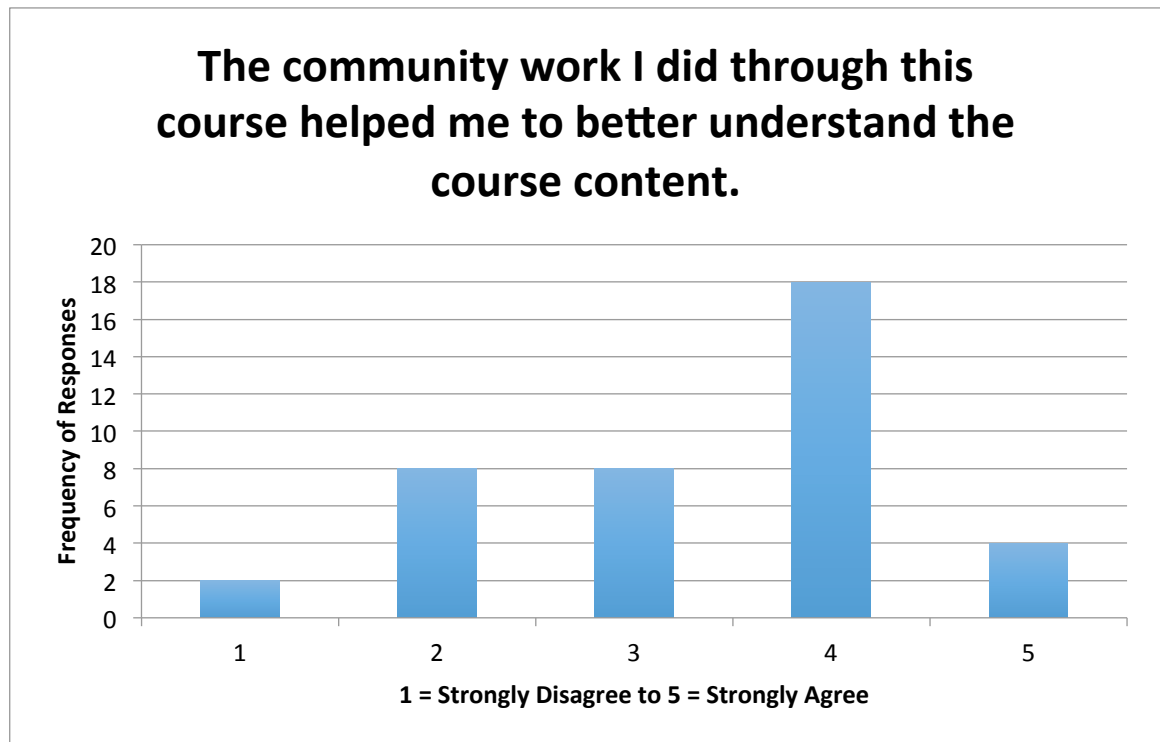


Figure 10: Summary of CBSL Survey Responses Related to Sensibleness

#### *Tabitha*

Recall that Tabitha had a very particular understanding of the algorithmic nature of mathematics from the start of the year. Being asked to creatively problem solve and apply mathematics to a life context without a step-by-step to a “correct” solution proved to be a challenge and uncomfortable for Tabitha. Because of this experience Tabitha reported a decrease in her FSMAS scores, but as was discussed above, perhaps it is best to consider what positive attitudes Tabitha had at the beginning of the year as misplaced in an improper understanding of mathematics, and therefore best understood as in reality

negative attitudes. Naturally then, Tabitha makes several statements regarding the antonyms of sensible, feeling confused. The following is from her final interview.

Tabitha: I learned I am not a statistics person and so I think at the beginning of the year, I think I understood the material better whereas now I'm just barely like, I don't understand what we've learned recently, so I'm confused.... I mean I've never been a math person but usually I can like understand basic concepts, but it was again just like the very final proposal, it just really confused me. I don't think I really understood the, like hypothesis testing and all the other tests that we learned and so then trying to like put them all together and then to analyze like data without having a problem set up, just kind of really made me confused.

To be fair, Tabitha also notes in her journal at the end of the year:

Tabitha: I have found it pretty hard to analyze the data... but I was absent the day when you explained this so I am feeling a bit lost.... Honestly I think it will [make more sense] the more I work but honestly it has kind of confused me.

While Tabitha was absent from class during a day at the end of the semester when the class worked together to consider how to address and analyze the data they gathered, she had been in class through the semester learning the typical statistical inference procedures that are covered in the AP Statistics curriculum.

A distinction should also be made between Tabitha being confused by the mathematics and the mathematics not appearing as sensible. Tabitha is not claiming that

the mathematics seems irrational and nonsensical to her, but just that she is confused by it. Tabitha doesn't even make the claim that the service-learning is the root of her confusion. Rather, Tabitha describes being confused by the material being learned in class and that the service-learning project in and of itself was not acting to rectify her confusion. Elsewhere in her journal, when asked about applying statistical inference procedures to the data that the students gathered:

Tabitha:        It makes sense to use the different methods we have used over the year.

So while Tabitha expressed her confusion and the difficulties that she experienced over the course of the year by encountering a new method of learning and applying mathematics, she viewed the service-learning project as a sensible way of applying the material from class. An apt summary of Tabitha's experience comes from one of her final journal entries:

Tabitha:        As the semester has progressed I have slowly understood more and more about what we are doing in this project. Honestly, at the beginning I really didn't like it, but I think the group work and the articles helped get us invested in the project. It is also fun to mix school work with community work. And even though I struggle with statistics I think it is helpful to see the practical use of math in real life situations, even if they are some what simulated. One of my favorite parts of the project has been reading the different articles specifically the news articles.<sup>4</sup> It's exciting to see how what

---

<sup>4</sup> Barragán, 2005; Bullock, 2012; Hall and Moore, 2013; Hari, 2015.

we are doing applies to current events.... I actually really understand the correlation between the project and what we are learning in class probably more than I understand what you normally teach in class, if I'm being honest.

Here, while Tabitha certainly addressed the usefulness of the project in its application, she also very readily admits that she understands the correlation between the project and the class more so than she understands the material in class. In other words, despite her confusion and struggle with the topics covered in statistics she was still able to see the sensibleness of the material through its use in a service-learning project. Tabitha serves as an excellent reminder that while service-learning may not aid every student in making perfect sense of the material covered in the course, it can help every student come to see mathematics as a sensible discipline, regardless of the student's own ability.

*Ava*

Ava classified herself as someone who is just not a "math person," but she still articulated the perspective that a math-based education was important to have.

Ava: I have never been particularly good at math or found it particularly enjoyable, however I recognize that learning math is an important part of becoming an educated person, no matter what field of study you choose to pursue.

This indicates that Ava views mathematics as rational and necessary discipline. As Ava further explained her views about mathematics she offered this interesting analysis of why math was not an enjoyable subject for her:

Ava: “Mathematics is enjoyable and stimulating to me”– I again responded “strongly disagree”. Classes such as Geometry and (thus far) Statistics have been a little more interesting to me because they involve reasoning. I have not enjoyed classes like Algebra or Precal at all, because I found myself just trying to memorize formulas.

Here Ava articulates that geometry and statistics were more interesting to her because they involve reasoning, whereas pre-calculus and algebra were very algorithmic. It is particularly interesting to note that Ava sees a distinction with geometry and statistics, the two classes in which she undertook service-learning projects.

*John*

John very clearly articulated his understanding of the connection between the project and the material covered in the course. While John doesn’t directly come out and say a statement along the lines of “I see math as sensible,” his clear articulation of what he sees as an obvious connection between the material in the course and the course project gives an indication that John very much views mathematics as a sensible and rational discipline – it is able to be understood and there exist clear instances where it is applicable.

John: I see the correlation between our class work on statistics and our project.... We have also decided if our data was categorical or quantitative (categorical or numerical data), which we have also learned in this class. We have been exposed to surveys, which has

prepared us for the language of the questions and how they might look like on a likert scale.

John also makes distinctions of when to apply different aspects of the material covered in class. In other words, he isn't simply articulating that the material is sensible in its application in a general way, but John clearly sees that certain statistical inference procedures make sense to be applied while others do not. While these quotes from John may relate more to the usefulness and applicability of mathematics more than its sensibility, but as mentioned above these categories aren't separated in black and white; there is a lot of overlap. John is speaking about applications but the way in which he is speaking about them he is clearly indicating his understanding of the sensibility of the material.

John: For the data I am using a 2 sample t interval, 1 sample z test, and chi squared test of independence. Analyzing the data has proved to be somewhat challenging. It was difficult at first because I felt like I was overwhelmed with information about all of these different questions. I also didn't really remember how to do some of the tests and it was frustrating when you didn't find one that was statistically significant. However, once I calmed down it wasn't really too difficult to actually do the calculations. It just took a decent amount of time to type out all the steps and show my work with different data displays. Overall I felt equipped to do the data analysis and it wasn't too difficult to see where certain tests would apply. For example, it wouldn't really make sense if you

performed a chi squared test of independence for how long you were homeless and the healthiness of your diet as a homeless person. I used an independence test for drugs and depression which was much easier to see a correlation (possibly) between the two. It also made more sense in certain situations to perform certain tests, which wasn't too difficult to see. Overall, I felt prepared to do the data analysis because I was familiar with the statistical models we were using and when I should use them even though I didn't perfectly remember how do the calculations.

*Charlotte*

Charlotte was one the clearest examples of a changing perspective in mathematics; growing in her productive disposition. For Charlotte, in her initial interview she made several statements on how confused she felt in math class. In other words she was articulating a negative view of the sensibility of mathematics.

Charlotte: Math problems seem to be more confusing to me because there's intricate little steps that you have to do. It makes me feel restless because the math problems that we're doing are way more complicated than 2 plus 2. You have to go through all of the things and work a long time on the problems. It takes time. I feel like you have to have like, a mathematical brain to understand a lot of math things.

Like Ava, Charlotte indicates that she finds confusing (not sensible) the intricate and formulaic problems that she was used to seeing in math class. When asked to make a



transition to applying mathematics to a real-life situation, Charlotte didn't see any sensible connection between the algorithms she has been taught and their application.

Charlotte: It's not confusing when someone teaches it or when it's on my notes, it's confusing when I actually have to apply it.

In her journal, towards the end of the year, Charlotte paints a different picture on seeing the sensibility of the material and its application through the service-learning project.

Charlotte: I was able to learn more about the [hypothesis] tests through the project and was able to understand them better by applying it to real life.

In her final interview, Charlotte gave a very different perspective of being able to understand the mathematics used in the project. At the end of the year she now sees the application of the material to a real-life scenario as making reasonable sense.

Charlotte: Also deciding what tests to do was a little bit challenging, but then once we discussed it in class, it was more easy to understand. The most exciting part of it was seeing that all of our hard work had paid off and that all of the notes that we had taken in class and everything that we learned this year was able to be applied to something other than math, in a math class.

### *Mason*

Mason openly expressed a very negative perception of mathematics at the beginning of the project. While he also expressed difficulty in understanding mathematics in his prior math courses, when it came to the data analysis of the project Mason demonstrated a very clear understanding of the material.

Mason: I have been examining the table in [Microsoft] Xcel [sic] and been adapting the data into charts. It has been a little bit difficult, but I've never had to do things like this before. The stats make sense.... The survey work has helped solidify material.

After reading the summary of Mason's experience above, for him to say in a very straightforward way, "the stats make sense" is a clear indication of him coming to see the material as sensible through the project.

#### *Summary on the Sensibleness of Mathematics*

In the case study group, each student came into the class and the project with very different views on how much sense mathematics made to them. While students might make assent to math being logical and rational, when that abstract statement was made more personal to their own experience they tended to express frustrations or confusions with the mathematics they see in school. However, through the project each student was able to articulate the sensibleness of the course material. The project served to solidify each students' understanding of the course and their ability to make sense of the mathematics involved.

#### *Useful*

The working definition of being useful is "being of practical use, serving some purpose." The main idea for this term is that it implies mathematics has a purpose, that the service-learning project has in some way aided the student in seeing the practical applications of mathematics. The figure below shows the responses of students to a question on the end-of-the semester Community-Based Learning student survey that pertains to this topic. While the quantitative response is helpful to see that the vast

majority of students would say that the service-learning project helped them to see the usefulness of mathematics (in fact, this was the aspect of productive disposition most clearly articulated by students), what follows is a summary of this notion in the words of the students in the case study.

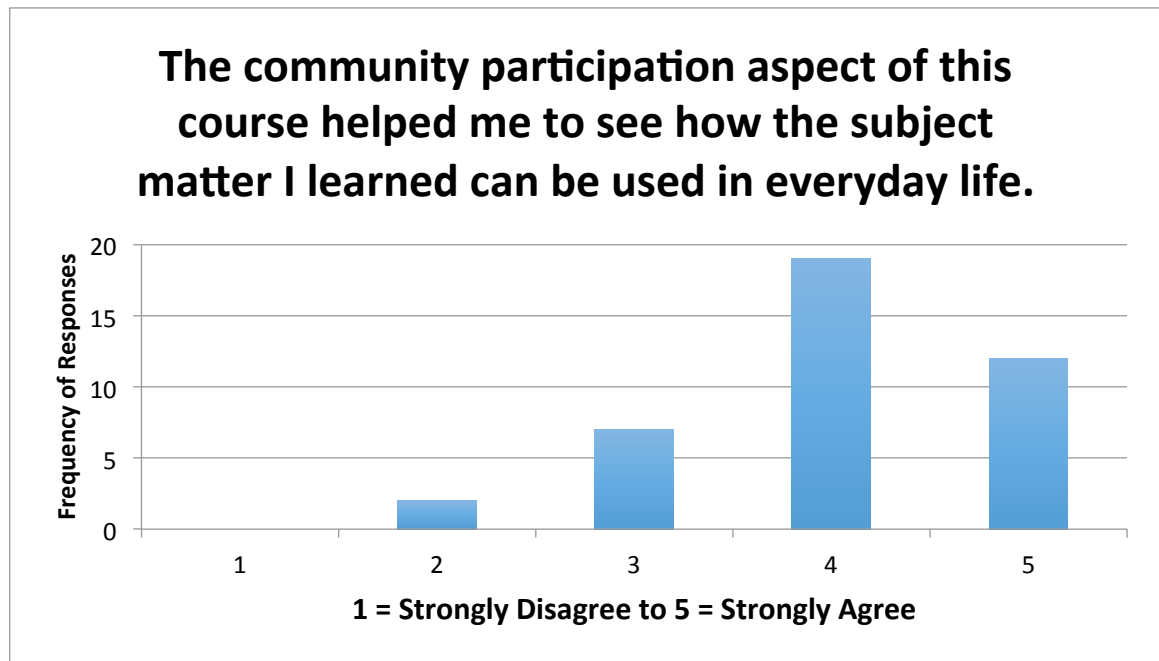


Figure 11: Summary of CBSL Survey Responses Related to Usefulness

#### *Tabitha*

Tabitha had nothing but positive comments to make about the usefulness of mathematics, despite her low FSMAS scores. As detailed above, Tabitha came into the project with an understanding of math being very formulaic, but she still assented to there being a value in mathematics; a notion that was instilled in her but might not have been internalized.

Tabitha: I see math as being valuable because basic math is necessary for most jobs.

Beyond the intellectual assent to math being practical for “most jobs,” Tabitha did show that she understood the usefulness of mathematics within the context of the course where she was learning it. In one of her final journal entries:

Tabitha: I understand why statistics can be useful for community service projects. I mean it [sic] necessary to be able to understand if the community service is actual [sic] helping.

In her final interview, Tabitha goes on to recommend the project for future classes.

Tabitha: I would recommend that they do so because it's a really cool concept.... I think learning to practically apply what your learning in the classroom is important.

Tabitha clearly sees math as clearly applicable and useful through her experience on the project.

*Ava*

Like Tabitha, Ava had nothing but positive comments in regards to understanding the usefulness of mathematics, despite lower FSMAS scores. Recall from above that Ava came into statistics having been instilled with an appreciation for mathematics, though that appreciation could best be characterized as an intellectual assent rather than her personal experience. Her personal experiences were expressed in a very negative light. Several quotes from her initial interview:

Ava: Even though I know math is important and I definitely am glad that I've taken it, it's always been my hardest class and I don't enjoy math.... Because obviously math is important for so many different things. Different careers, and even just getting into

college is important. Even though I don't enjoy it and I'm not good at it, I know that it's important and I know that it's necessary and I'm glad that I've taken it.

Again, much like Tabitha, Ava expresses an initial understanding of mathematics as useful but in a very generic way – math is useful for “different careers” or “just getting into college.” This understanding prompted Ava to come into the project with the motivation of gaining real-world experience with mathematics. From her journal at the beginning of the year when asked what the goals should be for the project:

Ava: As a class, we should have the goal of gaining practical experience in dealing with statistics.

When asked at the end of the year if the goals of the project were met, in her journal Ava again returns to assessing the goals through a lens of practical application.

Ava: Yes, because I applied [statistics] to a real life situation.

When asked in her final journal entry if she would recommend this project to future classes:

Ava: I feel that I now understand better how Stats can be used in real life. This is a useful take-away. I would recommend this project for future classes.

Ava reiterated this perspective in her end-of-year interview:

Ava: I definitely like the idea of having a service project that goes with what you're learning I think when you can apply what you're learning in that type of way. It just makes it more real world kind of.

Interviewer: What were your own personal learning goals for this experience, if any?

Ava: I think just being able to put it in a real world situation.

Interviewer: Okay. Do you feel like those goals were met?

Ava: Yeah.

However, as the project unfolded, Ava began to clearly see the usefulness of mathematics take on a much more personal meaning, speaking not only of realizing the useful application of statistics but also the rewarding feeling and the sense of meaningful purpose in that application. Again, from her final interview:

Ava: I think the most rewarding thing was to be able to see the presentation that they did and with the [partner organization] people there was cool to see the results to be presented to them and they can actually use this.... I think [service-learning is] good because it does allow you to get some real world perspective and at the same time it's not just something that's a useless real world perspective, like you are getting that perspective and you're also contributing something to people who can use that to do something good with it.

Ava clearly articulated an understanding of mathematics as useful throughout the course of the project. This perspective wasn't instilled through the project as Ava clearly had this perspective coming into the course. However, what was noticeable was how Ava's descriptions of the usefulness of mathematics transitioned from talking about it

abstractly as applying in “different careers” to seeing the immediate and meaningful application of statistics.

*John*

John came into this project as a high-achieving student with high FSMAS scores. Like Tabitha and Ava above, John began the project with an understanding of the usefulness of mathematics, but he was able to articulate it in more specific terms than either Ava or Tabitha during his initial interview.

John: I think [math is] necessary in the world because, I mean, obviously, you need it to do massive building projects and all these things. I don't know, I really like math, so I'm biased in this answer maybe, but I really like, for me, how factual math is.

By seeing mathematics as very factual and applicable, John saw the project as being a very natural occurrence in a statistics course.

John: I like having a project. If nothing was there at all, then I would be upset because I feel like this is a real-world kind of thing, and it's something that's real, so something like that.

But John also articulated further his understanding of the service-aspect of this project being motivated by his larger perspective of his education.

John: For a service project, I don't know, I feel like it's kind of part of our identity as Christians and people who are at [this school] and stuff to be people who serve and like to serve.

In his initial journal entries, John expands on very practical applications of mathematics and is even able to bring that application into his own personal context.

John: Math is an important part of our curriculum because it teaches us skills in life that we will use later in life. Just the other day I used math to find out that the premium gas ends up being cheaper for my car than the regular gas because of the better gas mileage. I also see myself majoring in math for college. Statistics seems applicable in everyday life and although I might not be constructing surveys and calculating statistics, I will be more aware of them and understand what they mean when I come across them in life. Math is helpful in so many ways and is seen in everyday life beyond the classroom.

In his journal entry at the very beginning of the year when he was asked to make a projection of how statistics might be applied in a service-project with the homeless outreach partner organization (prior to the project being assigned), John already had a notion of how statistics might be useful in this context.

John: It seems that statistics are very important in the community of [the partner organization] because they can compare the number of homeless people back then to now. They can also make predictions for the future on how many people will be homeless or maybe conduct experiments to see different percentages of what food the homeless people like the most. All in all, it seems like statistics plays a huge role in the excellent work that [the partner organization] performs for the homeless.



As the project unfolded John came to see how the class would actually be using statistics in applicable way in this project.

John:           The results that we obtained from the statistical analysis of our data will actually be beneficial to the [partner organization] people so they can get a better understanding of how they are making an impact on the lives of the homeless. At the same time we used statistical models that we learned for our class and applied in it a real-life situation to benefit the team at [the partner organization]. We served [the partner organization] by creating a survey (which we also learned how to do in class) and analyzing the data obtained from the survey.

Throughout the project John began to express the meaningfulness of the application – not only did he personalize the application of math into his own context (such as in determining gas prices), but it was something that he became emotionally invested in.

John:           It is exciting to anticipate the results of our survey and use data that could actually make a difference in someone's life rather than just be a problem on a piece of paper.... I take pride in the survey that we have made and am confident that we will achieve our goals.

Toward the end of the year John's view of mathematics as useful was not only validated, but it also grew as he realized ways that mathematics could be applied that he had not considered before:

John: I value my math education because it has important uses in everyday life and it is a field I want to go into in college... I have seen even more practicality in math in statistics. Statistics are seen in everyday life and I feel like I have a better understanding for them now than previously.

While at the beginning of the year, John could articulate an understanding of the usefulness of mathematics and also the usefulness of service to the community, at the end of the project he could articulate how those two concepts are intertwined:

John: I would still define a ministerium (service) as when a group comes together to selflessly benefit others. My view has somewhat changed on what this looks like. For this project we didn't do any manual labor, but still helped the people at [the partner organization] and the previously homeless people themselves. These people got a chance to talk to someone face to face and express their feelings, which brightened their day (at least for my person it did). So the definition remains similar to what I had previously, but this project changed my perspective on how ministerium manifests itself. We also benefited their community through the data displays and analysis that we gave them, which may help them understand the nature of the people living at the [the partner organization] village.

At the end of the project John not only articulates the usefulness of mathematics but he does so in a way that has clearly grown in complexity over the course of the project –

from initially discussing building projects or gas prices to now seeing a very personal and meaningful application of mathematics in the context of service. Unlike Tabitha and Ava above, John came into the project already expressing a very clear and specific understanding of the usefulness of mathematics. Yet, through the service-learning project, John's perspective on the usefulness of mathematics was still able to grow and broaden. So then, service-learning is perhaps not only valuable for introducing the usefulness of mathematics but also growing that understanding in students who already have an appreciation for it. In his final interview, John expressed the enjoyment he derived from the project for this very reason:

John: I would also say that it was very enjoyable as well to see the hard data that came out of it. It was also interesting and fun to have a project that was a real world situation instead of something that was made up.

#### *Charlotte*

Charlotte came into the course expressing negative attitudes towards mathematics and her prior experience with mathematics courses. Though she was classified as a high achieving student, she had low FSMAS scores at the start of the year. In explaining the difficulties she had with mathematics, Charlotte pointed to the application of mathematics – she understood that mathematics is useful and should be applied; she just couldn't see how she could ever do that herself. From her initial interview:

Charlotte: [Math is] not confusing when someone teaches it or when it's on my notes, it's confusing when I actually have to apply it. I still

come to math everyday... because it'll be useful to me one day,  
even if I don't really understand it right now.

As expressed in the previous section when examining Charlotte's comments on the sensibleness of mathematics, her confusion with the application of mathematics stemmed from her feeling unequipped to be able to apply what she had learned in real-life situations while at the same time feeling that applying what she learned was the expectation her teachers had of her. For Charlotte then, the connection to service piqued her interest in learning more about how to actually apply what she was learning in the classroom:

Charlotte: I was really excited to do [the service-learning project] because it was more of like, a hands on project.... I like how this project we're able to actually make a difference and serve someone instead of doing it for our own benefit. I was excited.... I think the community service part of it really gives a hands on experience.

In her journal entry at the beginning of the year, when asked to predict how statistics would be used in a service context, Charlotte offered several guesses and had already started to buy-in on the application of statistics for the partner organization:

Charlotte: I'm not exactly sure what to expect for this project. I know there are lots of numbers involving the homeless ie. meals, number of houses, clothing needed etc There are a lot of things we could estimate as a statistics class. We could do a project on projecting the number of homeless people [the partner organization] would serve in a given year. I think statistics is extremely important for

[the partner organization] because a lot of numbers and money is involved with making everything work.

Charlotte was able to see how statistics might be used by the partner organization and as the project unfolded she was able to clearly articulate how the course material was going to be applied.

Charlotte: [The partner organization] wanted to use statistics as a way to see how useful their ministry is. They want us to gather information on how the people's lives have changed before and after living on the streets.

This specific type of application, within the context of service-learning, seems to have led to extra motivation on Charlotte's part (despite her previous negative and confusing experiences of applying classroom concepts in real-life situations).

Charlotte: I am so excited to go out and give the survey. I hope it goes smoothly because it can be extremely useful to [the partner organization]. I'm excited to go out there and give a real survey to the people. I know it will be rewarding when the whole project is done. I'm dreading writing all the papers but I know it will be useful in the long run.

While elsewhere, on the FSMAS beginning of the year survey, Charlotte had mentioned that she would prefer to do as little work in mathematics as possible, here she indicates that the tangible application of the material is a motivating factor in doing the work that will be required to complete the project. Over the course of the project, Charlotte expresses her own personal growth in understanding the usefulness of mathematics.

Charlotte: I think we should value everything about our math education. I think it can be extremely helpful in everyday uses. I think my opinion has changed because I've grown to see math in a new and different way. There are several different types of math which can be useful in different areas of our lives. Although I'm not super interested in math I think we should all value it to some degree.

Whereas Charlotte mentions at the end of that quote of not being "super interested" in math, she comes to express a different perspective over the course of the project. One of the supplemental activities of the project was for students to read an article that summarized some statistics on homelessness for their local city. Here were Charlotte's thoughts on the article:

Charlotte: I am extremely surprised that there are more sheltered homeless people than unsheltered. I never knew that. Also shocked that the number of people going homeless is increasing. All of these stats are soooo interesting to me.

It is worth noting the extended "soooo" that Charlotte uses to emphasize the interest she is now finding in mathematics because of the personal connection that she has made to it through the project. When asked if she would recommend service-learning for other classes:

Charlotte: Yes I would recommend doing it for other classes! It was neat to see how the things we learned in class played out in the real world. It was a lot of work, but it was all worth it in the end.... I was able to learn more about the [hypothesis] tests through the project and

was able to understand them better by applying it to real life.... I enjoyed helping out the community with our math skills that we had learned in class.

It is worth noting that Charlotte's endorsement of the project is rooted in the usefulness of seeing the material from class applied in real-life situations that are meaningful.

Ultimately the service-learning project changed Charlotte's perspective of the usefulness of mathematics in her life.

Charlotte: This project has helped me understand that math can be useful in a lot of ways, they just might not all be obvious. Math will always have relevance in my life because math is everywhere and in everything.... This project has helped me realize that math can be very useful as an adult.

This is in stark contrast to Charlotte's perspective at the beginning of the year. Charlotte verifies this perspective in her final interview. Charlotte came to recognize unique ways mathematics can be useful in a service context:

Charlotte: [The partner organization] helped me understand that non-profit organizations can partner with math classes and partner with different things to meet the needs of something.

Even though Charlotte found the material challenging, she persevered through difficulties because of the value that she found in the service-learning project.

Charlotte: Deciding what [hypothesis] tests to do was a little bit challenging, but.... The most exciting part of it was seeing that all of our hard work had paid off and that all of the notes that we had taken in

class and everything that we learned this year was able to be applied to something other than math, in a math class.

As mentioned at the beginning of the project, Charlotte expressed her confusion and difficulty in trying to apply math outside of the classroom. By the end of the project Charlotte defines the success of the project in terms of applying the material:

Charlotte: I think this project was very successful. We were able to take the stuff that we had learned in class and apply it to something outside of the classroom, and that to me is successful.

Charlotte credits the service component of the project as playing a major role in her feeling of success in applying mathematics outside of the classroom.

Charlotte: I think service-learning is an awesome opportunity to learn more about math, because you're actually going out and doing stuff, and it's always helps for me and my brain to actually apply it to something, and to go out of the classroom and go to like [the partner organization], and I think it's very good.... Because I think it just helps children better understand what they're learning, because I know in the classroom, anything changing it up outside of the classroom is helpful, and it helps the children make a connection between service and learning, that those two aren't completely separate, but that they can actually be used together.

As to why the service-learning project had this impact on her, Charlotte mentions the engaging aspect of the service-learning project in applying course material, even leading her to feel like she does more math now than she ever wanted to before this year:



Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun.

In contrasting her beginning and end-of-year perspectives towards the usefulness of mathematics in her own words:

Charlotte: I think because before I just saw math as numbers in a classroom, and taking notes and equations, but now I can see math in every day activities and uses, so I think when I'm an adult, whether I'm reading the newspaper, looking at a magazine article, I can be like oh, they gave stats and I know stats.... Before, my answers are kind of the same, but thinking math is a waste of time, because before, once again, I just thought that math didn't really apply to anything besides math classes, because I never thought I'd be using sine and cosine in the real world or any of geometry in the real world, but now, through our service project and through the geometry project of creating a little tent thing for the RVs, I realized that math can be used in more ways than I thought. They can be used in the real world and not just in a classroom.

Like Ava above, it is significant to note that here Charlotte also credits her experience of a service-learning project in geometry her freshmen year as contributing toward this new

positive attitude. Charlotte experience a significant jump in her end of year FSMAS score, as might be expected from her positive journal and interview statements. When presented with her quantitative FSMAS results and asked if she thought it was valid to claim that her attitude towards mathematics has become more positive:

Charlotte: Yes, I do feel like my attitude in math has become more positive because ... I really think it's because of the service-learning project and because ... I'm trying to think of a different answer; I've been saying the same thing. Math is easier to understand when it's used outside of the classroom, and it's more relatable to me when I'm using it in real life situations, so I think just this realization that I can use math in every day activities helps me see it more positively because then I realize it's more useful, and it actually does matter.

#### *Mason*

Mason came into the project with a very negative view of mathematics as seen in his low FSMAS scores. Even though other students such as Ava and Tabitha above had lower FSMAS scores to start the year, Mason was the only one to link those low scores to his perspective that he will never use math in real life. While he could perceive a potential use of statistics, in general he saw math as a useless subject. When asked on the FSMAS survey if math has no relevance on his life, Mason responded “somewhat true.” When asked in his initial interview to explain his response:

Mason: With the somewhat true of me for no relevance in my life, that's never going to be entirely true for anyone obviously. Everyone uses math at some point. I see stats being incredibly helpful. I

might not be very good at it, but I can understand I'm going to have to use stats in the business world; like, that's going to be a thing. I'm going to be able to have to understand them, read them and be able to ... I guess, being able to do stats would cut out a middleman, but a lot of the stuff we learned, particularly in algebra and geometry algebra II, like dealing with imaginary numbers and stuff like that ... that kind of stuff with me is like, the numbers aren't real, they're imaginary. I've got to learn these ... I don't know.

While Mason mentions statistics as possibly being useful, it is not in any meaningful way – the focus is on potentially “cutting out a middle man.” Mason expands on this in his journal:

Mason: I expect to have little use for math out of High School. Stats is going to be helpful, and same with level 1 algebra, but as for application of the “imaginary numbers”... I’m not entirely convinced. But, maybe I will. Geometry too doesn't seem particularly applicable, but I know school is just teaching you how to win at the game and little of what you learn will be applied after high school.

Also during his initial interview:

Mason: I just felt like, "When am I ever going to use any of what I'm learning right now," specifically about math and science.

When asked in the initial interview to explain his journal statement of “school is just teaching you how to win at the game,” Mason continued to discuss how what he was learning at school seemed completely useless and not applicable to life.

Mason: That might be true that stuff like imaginary numbers and stuff, like I may never use that, but the grades are a game and that's the score and you've got to score in order to win the game. A lot of it's like, they're not seeing what information do you know, it's can you know the information? Can you understand how to succeed in the environment you're given? That translates a bit. College, so we're taking an investment on this kid, and then that goes on to the business world with like, "So this kids learned how to win in numerous different scenarios. We can take a chance on him, too."

Mason's perspective on school, and math and science in particular, was that its primary purpose was simply to show colleges that you can be successful at some task that you have been given. Mason could not have had a more negative understanding of the usefulness of his math education. However, Mason hinted that through the service-learning project he might be open to his perspective changing. When asked in his initial interview about his thoughts looking forward on the service-learning project:

Mason: I was optimistic. I love to see practical applications of things. I think us being able to use stats and, I guess, our status in our situation in life to be able to help other people. I love doing that. I love helping people. I love investing in other people; like building relationships. Not so much with the math part. I think that's an

added benefit that we can help a broader scale of people, but I was excited. I thought it would be a lot of fun. That's one of the reasons I was looking forward to stats just because I knew we got to do a lot of like cool project stuff.

Mason clearly indicates that he connects with the relational aspect of this project. While he held a very negative view on the usefulness of mathematics in his own life, he was open to engaging in the service-learning project. With this opening, Mason expressed a clear change in his tone about the usefulness of mathematics at the end of the year. All of the above negative statements were all taken at the very beginning of the year. At the end of the year, Mason had only positive things to say about the project, specifically in regards to the application and usefulness of mathematics. In his final interview when asked to look back on the project and share his thoughts:

Mason: (laughs) I loved it. I love ... Service is awesome. Being able to see the benefits of ... You are actually impacting these people's lives. Not off of a 'look what I can do,' but look at that. We can actually make a difference in our community, and we can use a special set of skills to make math fun. Which for me, math has never been fun. Since I've been a little kid, math has never been fun. It's always been hard for me. It's always been a task for me to sit down and do my math homework. This was actually enjoyable. It was cool to see. This isn't imaginary numbers. This is real tangible things that we're doing. It just made it seem a lot more real.

Through the service-learning project Mason has a drastic change in his expression of the usefulness of mathematics. The relational component of the service-learning project connect with Mason and by the end of the project he is expressing that math was “actually enjoyable” in its applications. Mason went beyond just the relational descriptions, indicating the interest he found in the course material itself:

Mason:           Where I thought I saw the stats come in, you could look at the spreadsheet after all the spreadsheets were done, and make charts and graphs and then do the equations on ... Okay, this is what it actually looked like and there was no correlation between money and happiness. I thought that was cool to be able to look at stuff and see, wow, I actually used the stats and statistics skills that I learned this year to hopefully make a difference in our community.

Through the project Mason was able to express “I actually used the stats and statistics skills that I learned this year to hopefully make a difference in the community.” As mentioned previously, it is important to note the use of the term “actually.” Whereas Mason previously only saw math as potentially useful for “cutting out a middle man” in the future and definitely not applicable in his immediate context, that perspective has now changed. When asked to comment in his final interview as to why that change has occurred:

Interviewer:   Looking at number 11 [in the FSMAS survey], "I study math because I know how useful it is." In the fall, you said, two, somewhat untrue and in the spring, a four, somewhat true. I wonder if you could just talk about that.

Mason: I entirely attribute that to stats, just the class itself. It felt a lot more practical and, as well as, with our service-learning project. I saw a lot of real things. Real things were happening there. It really showed me, this isn't some head in the clouds thing if you're not going to be an engineer. I saw a lot of real application to it.... in terms of math, I saw stats as a lot more ... I'm going to hold this and carry it on into college and it's still going to be hard but it is something that I could really see myself using.

### *Summary on the Usefulness of Mathematics*

While all students in the case study expressed their understandings differently, all of them indicated that the service-learning project improved their perspective on the usefulness of mathematics. A typical response at the beginning of the year was to offer an assent to math being useful, but for somebody else in some different job, in some distant future. After the project, every student was able to articulate how the math they were learning was useful in their immediate context. The usefulness of mathematics became a more personal experience.

### *Worthwhile*

The working definition of being worthwhile is “being rewarding, valuable to justify time or effort spent.” The main idea for this term is that it implies mathematics is worth putting time and energy into learning; mathematics offers something valuable and rewarding for everyone. In the context of this study this means that the students indicate that the mathematics involved in the service-learning project was an important task to undertake, has beneficial outcomes, and was worth the effort that was committed. The

trick here is distinguishing between the students communicating service in general as worthwhile and the mathematics behind the service-project as being worthwhile. The figure below shows the responses of students to a question on the end-of-the semester Community-Based Learning student survey that pertains to this topic, asking students if the service-learning project contributed to their appreciation of the course content. The question was posed this way to draw a distinction between the service and the mathematics behind the service. To have an appreciation for something is to demonstrate gratitude for having learned it, thereby seeing the experience as worthwhile. While the quantitative response is helpful to see that the vast majority of students would say that the service-learning project helped them to develop a deeper appreciation of the course content, what follows is a summary of this notion in the words of the students in the case study.

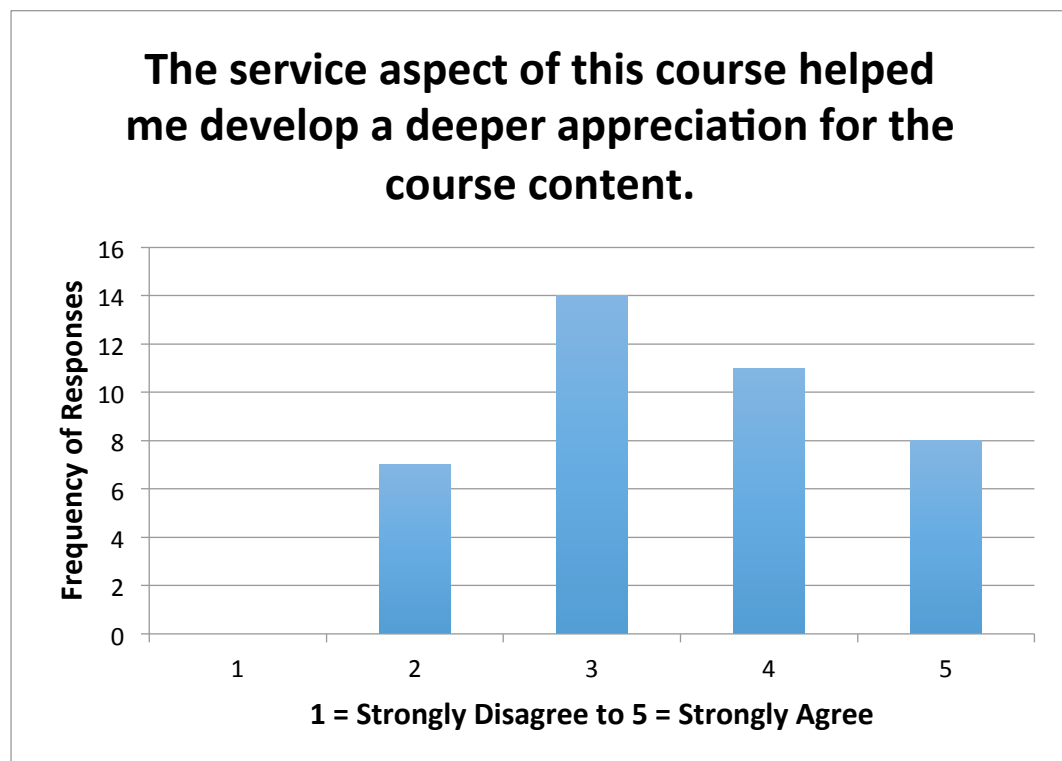


Figure 12: Summary of CBSL Survey Responses Related to Worthwhileness



*Tabitha*

To find something worthwhile is to value in it. When it comes to mathematics and math education, Tabitha wrote early on in her journal:

Tabitha: I think you should value your math education because it is important however I think depending on what kind of person you are it will determine how much you value it. For example I probably value my math education least of all the educations I value but it still has value.

Tabitha is expressing the notion that she is not a “math person” and therefore finds other aspects of her education more valuable. She expands on this elsewhere in her journal.

Tabitha: I think that we should value our math education just because it is an integrated part of our everyday life. I also think most of life will require some sort of basis in math, so in that sense we should value it just because it is necessary for our success. Some people will value it more than others based off of what their natural gifts are, I am not mathematically inclined so I would gander to say that I do not value my math education as much as I should, but even then I do still see it’s value and significance in everyday life. I mean in my own life even working at my summer jobs I have to use a lot of basic math, so practically it’s a valuable skill.

While she still expresses seeing value in her math education, this is more of an assent to the notion that all education has value rather than a personal understanding of the value of mathematics (as seen in the explanation of Tabitha’s case above). Any personal

understanding that she does relate is applying “basic math” in her part-time jobs. Later on in her journal Tabitha states one thing she found in the project was:

Tabitha: I realized I really hate data analysis.

While this is not an explicit statement that more advanced mathematics is not worthwhile, based on the definition of worthwhile above, being worth the time and effort spent, stating that “I really hate” something can be inferred as an indication that the activity is not worth the time and effort spent. This inference becomes more justified in the bigger picture of Tabitha’s case – a student who actually saw declines in her attitude towards mathematics because she was being asked to apply concepts in a creative way rather than simply follow a prescribed algorithm. Rather than speaking of the service-learning project as a rewarding experience, for Tabitha it was an uneasy one, as she mentioned in her final interview:

Tabitha: Yeah, I think because we've never had to practically apply [math] before and because it's like a completely new concept for us. I think I just really, it made me uneasy to know that like, I couldn't, like that that was extremely difficult for me to know that like I can learn concepts in the classroom but when it comes to practically applying it, I was kind of, not able. Like maybe if we had been like doing service projects like from freshman year to now, then I would be like more comfortable with it and I would like be able to think outside the box of what we're taught but, yeah.

For Tabitha, the uneasy feeling resulted from thinking that she was comfortable with math, but that definition of math of finding algorithmic solutions in a classroom now had

to change. Once she was asked to creatively apply what she had learned and she realized that she was not finding as much success as she had in previous math classes, she had to realize that she was not as comfortable with mathematics as she thought she was. As discussed above in Tabitha's case, Tabitha was forced to confront her misconceptions of what it means to apply mathematics outside of the classroom. Gomez-Chacon and Haines (2008) offer examples of a positive attitude toward a false perception of math being classified as a negative attitude. In other words, seeing math positively because the student views it as a set of procedures to be memorized and they feel capable enough of doing that, could legitimately be understood as a negative attitude toward mathematics. In that light, the uneasiness that Tabitha reported could be understood as actually being worthwhile. When asked to address her perceived negative attitude towards mathematics Tabitha herself noted in her final interview:

Tabitha:        That mostly like comes from uneasiness, not like Math makes me uncomfortable, I don't think it's a bad thing.

Tabitha herself realizes that the uneasiness the project introduced into her perception of her mathematical ability was actually a good thing. It was worthwhile. Finally, it is significant to note that Tabitha's own answer for the uneasiness she felt would have been to have had more experience with service-learning and prior experience applying mathematical concepts. Her solution was to do more of it, not to stop doing the project. Unlike Ava and Charlotte, who have mentioned their prior experience with service-learning as being important, Tabitha was not one of my students in geometry and so she had no prior experience with service-learning.

Elsewhere in her interviews, Tabitha does note the rewarding and worthwhile experience of the project. In her initial interview, when asked what she was looking forward to about the project:

Tabitha: The project is just an added perspective I guess. It's an added project to help us understand what we're learning better, so I think I like that better just because it helps break up the monotony. Is that what it is? Monotony of the classroom where you're just only learning one side of something so you're taking notes on the board and then writing it down and not really seeing how it works in other situations.

Here, Tabitha expresses the benefit of being able to see “how it [math] works in other situations.” Having the opportunity to see the application of mathematics has a big impact on Tabitha’s perspective of mathematics being rewarding or worthwhile (again speaking to the overlap between sensible, useful, and worthwhile). In the final interview Tabitha expresses what she found rewarding:

Tabitha: Giving the survey and even creating the survey was really rewarding and then to like have the final product that you actually use was really rewarding.

One of the biggest endorsements for seeing mathematics as worthwhile (worthy of time and effort) through the project is if a student recommends the project again.

Tabitha: I would recommend that they do so because it's a really cool concept and.... I think learning to practically apply what your learning in the classroom is important.

*Ava*

In her initial journal entry, done in response to taking the beginning of the year FSMAS survey, Ava expresses the exact opposite of seeing mathematics as worthwhile:

Ava: “Mathematics is enjoyable and stimulating to me” – I again responded “strongly disagree.” I often find math very frustrating and it is just not as enjoyable to me as other classes. I find myself having to work much harder to attain grades that would disappoint me in other classes, and also not enjoying the work as much as I do in other classes. To be honest, I feel a little bad saying that– but it’s absolutely the truth.

While one does not necessarily have to find mathematics enjoyable to find it worthwhile, Ava is clearly expressing is that mathematics, to her, is not worth the effort that she is having to put into it; mathematics is not worthwhile. During her initial interview, Ava states that while not enjoying math, she still finds it important subject. This seems to speak to the worthwhileness of mathematics, but at the same time feels more like an intellectual assent rather than a true personal belief. Ava sees math as important because she believes she is supposed to.

Ava: Even though I know math is important and I definitely am glad that I've taken it, it's always been my hardest class and I don't enjoy math.... Because obviously math is important for so many different things. Different careers, and even just getting into college is important. Even though I don't enjoy it and I'm not good at it, I know that it's important and I know that it's necessary and I'm glad that I've taken it.

Elsewhere in her journal:

Ava: I value my math education because I know that having a solid base of math is important for nearly any career choice (and for just generally functioning as a person in 2016). Also, I value the liberal arts goal of educating the whole person. Even though math is not my strongest subject, taking math is valuable because it makes me a more well rounded person.

And finally, Ava is explicit in noting that she sees mathematics as worthwhile as purely an intellectual assent:

Ava: “Mathematics is a worthwhile and necessary subject”— I still agree with this statement. I think I really value the [school]/general liberal arts education goal of educating the whole person and having a strong core curriculum in all disciplines. So, even though I’m not very good at math nor do I enjoy it much, I recognize that it is important and that I wouldn’t ever be a well educated person without taking math. With that said, I don’t plan to use math in my college major or in my career, so maybe I really just agree with this statement on the principle of becoming a well educated person someday.

When asked to clarify this journal entry during her final interview:

Interviewer: The last thing is what you said in your journal entry of saying what you said about working harder but not enjoying it as much, but then at the same time recognizing that, to be considered an

educated person you have to have math, and so seeing value in that. I was wondering if you can expand on that last line in your journal entry of agreeing with that statement on principal ... of math being worthwhile.

Ava: Yeah. I think it's just been drilled into me through [this school], because [this school] focuses so much on having a strong core curriculum and saying you need to understand all disciplines to be a well educated person even if you don't like this one subject and even if you don't want to do that in college or in your career, it's still important that you understand it at least at a basic level. I think I've come to value that and understand why that is an important thing.

When discussing mathematics in a service-learning context, Ava's statements on the worthwhileness of mathematics begin to become more personal. At the end of her initial interview, Ava was asked about her perspective of service-learning projects:

Ava: I definitely think [service-learning projects are] awesome. From geometry, I don't remember every single theorem that we learned at all, but I definitely remember doing that project for [the partner organization], and I remember working on that with my group and putting together.... on the program and presenting it to the class. I think it definitely is more effective for getting a general point across.

Ava specifically recalls her prior experience of being involved in service-learning in geometry. While she doesn't remember every theorem, she remembers vividly her involvement in service-learning and saw it as a positive experience. When looking forward to how service-learning might be used in statistics:

Ava: I think it's really cool to be a part of proving that it helps and if [the partner organization] can use this data in some way to show people that this is more the approach that we need to be taking towards fixing homelessness. I think that would be really cool, to have been a part of that.

Ava expresses finding value in the service aspect of this project. Here it is important to note that while some may argue that Ava is simply finding the service valuable and not the mathematics, based on a well-designed service-learning project, that is a hard claim to make. In a well-designed service-learning project the course content is being applied in a service context. So then, if a student mentions finding the service experience worthwhile, that service experience necessarily involved applying the course material.

In her final interview Ava expresses her understanding of the connection between the content of the course and the service component and how rewarding that connection was for her:

Ava: I definitely like the idea of having a service project that goes with what you're learning I think when you can apply what you're learning in that type of way. It just makes it more real world kind of.... I think the most rewarding thing was to be able to see the presentation that they did and with the [partner organization]



people there was cool to see the results to be presented to them and they can actually use this.... This project has meaning and it has a clear use, so we're not just going out and measuring something random.

*John*

John came into the year already expressing a very positive attitude towards mathematics; possessing high FSMAS scores and stating that he plans to major in mathematics in college. In his initial interview, when asked to expand on why he has such a positive view of mathematics, John indicated that he really felt like studying math was worthwhile:

John: I feel fulfilled when I get the right answer, I would say. Yeah, I'd probably say I just feel fulfilled and kind of satisfied when I get the right answer on some question.

John is clearly expressing finding the effort that he puts towards mathematics as being worth it. While John expressed the value of mathematics in and of itself, he also brought that perspective to the project as well:

John: When it was first assigned ... I was kind of excited because I remember doing the gazebo project in geometry, and that was a lot of fun.... I kind of remembered that and thinking like, "Wow, we actually did something that made a difference for an organization that helps homeless people."

John was one of the students who I had previously taught in geometry and he had participated in a service-learning project in geometry. John went on in the initial

interview to distinguish that it wasn't merely the application of mathematics in the project that made it worthwhile:

John: A project without service, it would be fine, but I feel like it wouldn't be as fulfilling because we get to work with these homeless people and see what they're like. Yeah, I would say that I would feel more fulfilled by the service project, I don't know, because we're actually benefiting people... it's not just a piece of paper kind of project.... I'm also happy and fulfilled because I feel like we're benefiting [the partner organization] as an organization. I feel like I'm not doing it because I have to do it for school, but I'm doing it because this would be a cool service project to do or something like that.

John had already mentioned that he finds fulfillment in mathematics but he also makes it clear that his fulfillment increases with the integration of service into the course content. This is important to note as service-learning projects can be beneficial not only for the students who come into a course with a negative attitude towards mathematics but for there are still gains to be made for students who already have a positive attitude towards mathematics as well.

In his journal, John validates the value he places on mathematics:

John: I value my math education because it has important uses in everyday life and it is a field I want to go into in college... I have seen even more practicality in math in statistics. Statistics are seen

in everyday life and I feel like I have a better understanding for them now than previously.

In addition to the application of mathematics, John also discusses further the fulfillment he finds in the service-learning project:

John: It is exciting to anticipate the results of our survey and use data that could actually make a difference in someone's life rather than just be a problem on a piece of paper.... I enjoyed coming up with the conclusions at the end that actually made sense and benefitted [the partner organization]. It was cool to see the fruits of our labor come to so many different conclusions. At the same time, performing these [hypothesis] tests ended up being painstakingly long and tedious. However, it was worth it to me in the end because we finally reached many conclusions from the data we collected and actually contributed to a great organization by coming up with real answers in a real-life situation.

Here, John clearly indicates the worthwhileness of mathematics: though the statistical calculations were "painstakingly long and tedious" it was worth the time and effort in the end because of the tangible benefits John was able to see through the service-learning project.

In his end-of-the year interview, John reiterated the value that he found in the integration of course content with service to the community.

John: I would also say that it was very enjoyable as well to see the hard data that came out [of] it. It was also interesting and fun to have a

project that was a real world situation instead of something that was made up.... just doing the project and the gazebo project, from freshman year, definitely aided my learning.... I feel like it was rewarding seeing the results that we had because we had compiled all this data and everyone's doing [hypothesis] tests at the same time. Seeing that most of the results were significant was very rewarding and I feel like we were actually helping [the partner organization] which feels good inside to actually do something for another organization that helps the homeless in that way.

John articulates the success of the project not only in terms of the results that the project produced but in terms of what he learned about himself as well. He clearly views the project as a worthwhile endeavor:

John: I would call [the project] a success because I learned new things about myself and my situation and I got to see a different side of life through all the homeless people living at [the partner organization]. I got see this incredible community, and I'd call it a success because of all the results that we had as well. I feel like regardless our entire class just learned new things about themselves and about the value of community as a whole.

What John found valuable was learning about community and about himself. It is important to note that he intertwines this language with the statistical results of the project as well. The application of the content in a service context was clearly worthwhile for John:

John: I could write [statistics] on my paper all I want but I don't know what it actually looks like in the real world. I feel like doing it for the community makes it even more special because it makes you feel good inside that you did something for someone else and your helping these people that are less fortunate than you obviously. I feel like the interactive side of it is very important, and is needed as opposed to just staying in the classroom and just learning the material.

Even though at the very beginning of the year John expressed finding fulfillment in just the solving of a mathematics problem, he now finds worth in a deeper understanding of what mathematics is and how it can be applied.

*Charlotte*

In her initial interview and initial journal entry, Charlotte indicated not seeing mathematics as a worthwhile endeavor. She indicated very negative feelings towards the subject with indications that mathematics was not worth the time and energy that she committed to it.

Charlotte: [Math] makes me feel uncomfortable, restless, irritable, impatient because unlike literature or history you can just write out your thoughts or whatever. Math is like, certain numbers and certain things. There's a right or wrong answer. If you don't get the right answer then it's like, oh, you get everything wrong basically.... Math problems seem to be more confusing to me because there's intricate little steps that you have to do. It makes me feel restless

because the math problems that we're doing are way more complicated than 2 plus 2. You have to go through all of the things and work a long time on the problems. It takes time. I feel like you have to have like, a mathematical brain to understand a lot of math things. Taking mathematics is a waste of time to a certain extent. Learning sine and cosine will probably never come in handy in my life.

For Charlotte it is important to note that these negative sentiments, seeing mathematics as not being worth the effort, were only expressed at the beginning of the year. As she engaged in the project her expressions became much more positive about mathematics. Despite feeling uncomfortable with mathematics Charlotte still expressed excitement (which is really just having a willingness to put forward energy towards something) when asked about the service-learning aspect of the project:

Charlotte: I like how this project we're able to actually make a difference and serve someone instead of doing it for our own benefit. I was excited.

In her journal entries as the year progressed, Charlotte indicated confidence in finding the service-learning project rewarding.

Charlotte: I did not expect this to be what we were doing for the project. For some reason I thought it was going to do with estimating numbers or something. I am glad that we are doing a survey now.... I am so excited to go out and give the survey.... I'm excited to go out there and give a real survey to the people. I know it will be rewarding

when the whole project is done. I'm dreading writing all the papers but I know it will be useful in the long run.

Despite the mathematical work involved in the project, the type of work that Charlotte expressed made her feel uncomfortable and restless, by placing that mathematical work in the context of a service-learning project Charlotte is now able to see the work as being worthwhile. When asked at different points during the year why she should value her math education, Charlotte's responses can clearly be seen to be evolving; to seeing mathematics as valuable to her life currently (specifically in the context of service) and not just valuable at some undetermined future time:

Charlotte: (Beginning of year) I should value by math education because it will be important to me later in life. I may not see a use for it now but I know the basic understanding of math will help me solve problems later on.

(Later in the year) I think we should value everything about our math education. I think it can be extremely helpful in everyday uses. I think my opinion has changed because I've grown to see math in a new and different way. There are several different types of math which can be useful in different areas of our lives.

Although I'm not super interested in math I think we should all value it to some degree.

(End of year) I still think math is very valuable even more so after the project is over. I also think ministerium is a way for us to serve the community with gifts and talents. Now, I know I can serve the

community with mathematics! That is something I would have never thought of until this year.... I have had a more positive attitude on math thanks to our awesome survey project!

By the end of the year Charlotte was expressing her work in mathematics not in terms of it bringing discomfort and uneasiness but rather as enjoyable, valuable, and worthwhile.

Charlotte: This is a lot of [hypothesis] tests to run and a lot of data to report. It has been cool seeing our project come all the way through. I have enjoyed each and every step.... Yes I would recommend doing it for other classes! It was neat to see how the things we learned in class played out in the real world. It was a lot of work, but it was all worth it in the end.

In her final interview, Charlotte is able to look back over the year and speak of all the work put into the project as “paying off” – that is, being worth the time and energy put into it.

Charlotte: The most exciting part of it was seeing that all of our hard work had paid off and that all of the notes that we had taken in class and everything that we learned this year was able to be applied to something other than math, in a math class.

Charlotte is also clear in her final interview to note that she doesn’t simply see the service aspect of the project as being worthwhile, but that her understanding of the value of mathematics has been impacted as well.

Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning



project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun.... Yes, I do feel like my attitude in math has become more positive because ... I really think it's because of the service-learning project.

*Mason*

Mason came into the project with the lowest beginning FSMAS survey results of any student in the case study. Mason began the year expressing a great deal of frustration when it came to mathematics – finding it not worth the effort being put in. In his initial interview he gave an indication of his understanding of math as formulaic and algorithmic:

Mason: For me, I see being able to read a chapter in a book and be able to break it down and define character's motives and thought processes and be able to analyze that in the more free thought not so structured. A lot of aptitude things and different tests I've taken, they all said I struggle following multi-step issues. Issues where you start at one place and follow like a set guide of instructions to reach an end. I guess that's a lot of what math is. To me, that doesn't seem like it's incredibly like critical thought based. You can't really provide insight in to it. It's just like, this is what you were given and you have to put that in the correct slot where it belongs.

He also expressed how he saw mathematics as having little relevance to his life:

Mason: With the somewhat true of me for no relevance in my life, that's never going to be entirely true for anyone obviously. Everyone uses math at some point. I see stats being incredibly helpful... but a lot of the stuff we learned, particularly in algebra and geometry algebra II, like dealing with imaginary numbers and stuff like that ... that kind of stuff with me is like, the numbers aren't real, they're imaginary. I've got to learn these ... I don't know.

This perception of mathematics as formulaic and not relevant to his life led to a great deal of experienced frustration on Mason's part:

Mason: I think on top of that, math, it frustrates me. The amount of time I put in to math is a lot, a lot more than I do to any of my other classes. It doesn't reflect in grades. In humanities, where I can put as little in as like ten minutes a night making sure I understand the themes, and then being able to go in and get A's in the classes consistently. Whereas in math studying four or five days before a test pretty heavily, redoing all the notes problems, redoing all the reviews, if I didn't ... When you come to the waste of time aspect of it, I feel like I would struggle whether I studied or not, but the part of me ... I still study because I want to do well and I still think there's that chance that I'll do well, but the amount of time I put in and not seeing results, it's frustrating, it's difficult, and it seems like I'm kind of wasting it.

Mason very clearly articulated the opposite of seeing mathematics as worthwhile – mathematics was clearly not worth the time and effort that Mason spent trying to learn it.

However, all of these negative remarks occurred during Mason's initial interview. Despite starting the project with this perspective of mathematics, and with low FSMAS scores, by the end of the project Mason saw a drastic improvement in his disposition towards mathematics. After all of the coding was completed for this study, Mason actually had the highest number of coded instances of seeing mathematics as worthwhile compared to any other student in the case study, including John. Even in his initial interview Mason gives an indication of his openness to involve himself in service-learning and even his excitement at being able to do this in a math class.

Mason: I was optimistic [when I learned about the service-learning project]. I love to see practical applications of things. I think us being able to use stats and, I guess, our status in our situation in life to be able to help other people. I love doing that. I love helping people. I love investing in other people; like building relationships. Not so much with the math part. I think that's an added benefit that we can help a broader scale of people, but I was excited. I thought it would be a lot of fun. That's one of the reasons I was looking forward to stats just because I knew we got to do a lot of like cool project stuff.

While Mason initially makes a distinction between the mathematics and the service component of the course, he goes on to indicate how the service aspect has led to increased enjoyment in doing the mathematics of the course:

Mason: Yeah, for me [the service-learning project has] made stats a lot more enjoyable; math a lot more enjoyable overall. Knowing that there is like practical application for what we're learning. I really enjoyed that.... That was really fun to see something that I've traditionally really disliked a lot actually bring me some enjoyment and happiness to see we could use that to really make people's lives better and help get them to a better situation.

Elsewhere, Mason elaborates on what exactly about the project has helped him change his perspective from one that found mathematics frustrating to one that found mathematics enjoyable and worth the effort. When asked again about his perspective on service-learning:

Mason: Personally, I love it, especially like I'm not huge on math and not huge on sitting in a classroom at all anyway. I love harknesses (discussion based learning) and stuff, being able to engage with people and doing things other than just like getting a lecture, so having an awesome thing like a service-learning project, being able to ... There's something more than just taking a test and like getting a grade. I know it is like, it's a class, it's a game, but like being able to see something that's like, it makes me subconsciously like stats more and want to be invested in it because ... Partially because I've got a group that I'm working with. I don't want to let the group down. When we go survey people, I want to do really well there. Stuff like [the guest speaker's] talk today was great. Then just

seeing that there's more to the class than the class itself, especially with [this school]. I like how that works together.

Clearly for Mason the service component of the project serves as great motivation. While initially captured by the personal interactions, Mason is sure to emphasize the importance of doing the mathematics well so that the results of the project are beneficial. His perspective on the benefits of the project clearly indicates that he sees the mathematics as being worthwhile to undertake.

Mason: I know that I know have a heart for people that are homeless and struggling. If we put that together, I really, really, really think that we can do a great thing. I'm not just saying that. I think this can be hugely beneficial.... I think that can be really, really, really helpful, especially for people that are struggling, and that. It's difficult for nonprofits and charity organizations to be able to do something like that. I think it's difficult for them to be able to have a hundred surveys just done with really no trouble for them at all. I think that's going to be really beneficial, and I think you can do it really, really well.

Mason's use of "really, really" on multiple occasions serves to emphasize the significance he places on the outcome of the project and the worthiness of the endeavor that he is undertaking. In his journal, Mason indicates that the worthwhileness of the project is also being found in the course material and not just the personal interactions that accompany the service component.

Mason: As of rewarding experiences, the story and relationship with [the person we interviewed] was the best, but.... I enjoyed analyzing the work we did

In his final interview, Mason verified his perspective of the project, and the mathematics contained therein, to be a worthy endeavor.

Mason: I loved the project. I felt like we could really help a lot of people and... I think using statistics to do it was a good thing too.

Elsewhere in his final interview:

Mason: I think [service-learning] can destroy a lot of biases people have toward homeless people. I think we can really help [the partner organization] through what we did.... It was nice to be able to use statistics to be able to create the final report and see the fruits of our labor.

Mason clearly articulates the benefits in seeing the “fruits of our labor,” indicating the worthwhileness of the service-learning project and the mathematics involved to complete it. While Mason admittedly became connected to the project with the prospect of relationally connecting with others, at the end of the year he still concedes seeing the value in the mathematics he undertook; mathematics he had previously felt very negative towards.

Mason: Yeah, I think I learned a lot more about people through the project than actually using Chi-squared Goodness of Fit test or Tests for Independence. But, I think both things are incredibly valuable.

When asked about his perspective on the service-learning project, Mason was quick to point out how valuable he found the experience, even interrupting the question to get that point in. he goes on to draw a clear distinction between his perspective of mathematics at the beginning of the year and his perspective at the end of the year.

Interviewer: The question is, what is your impression of service-learning in general ...

Mason: (interrupts) I love it. (laughs) I loved it. I love ... Service is awesome. Being able to see the benefits of ... You are actually impacting these people's lives. Not off of a 'look what I can do,' but look at that. We can actually make a difference in our community, and we can use a special set of skills to make math fun. Which for me, math has never been fun. Since I've been a little kid, math has never been fun. It's always been hard for me. It's always been a task for me to sit down and do my math homework. This was actually enjoyable. It was cool to see. This isn't imaginary numbers. This is real tangible things that we're doing. It just made it seem a lot more real.

Mason indicates the benefits of using a special set of math skills to reach a meaningful and worthwhile conclusion and lead to an all around enjoyable experience. Mason goes

on to specify the meaningfulness of the results that were achieved through the mathematics of the course:

Mason: Where I thought I saw the stats come in, you could look at the spreadsheet after all the spreadsheets were done, and make charts and graphs and then do the equations on ... Okay, this is what it actually looked like and there was no correlation between money and happiness. I thought that was cool to be able to look at stuff and see, wow, I actually used the stats and statistics skills that I learned this year to hopefully make a difference in our community.

Mason experienced one of the largest positive changes in his FSMAS survey scores at the end of the year. As the final question of his final interview, Mason was asked if he thought that the FSMAS results were correct and that his attitude towards mathematics had become more positive.

Mason: Yeah, definitely, much more positive. It was hard, don't get me wrong and I'm not saying I'm no good at math thing didn't change, but I do think ... I should've changed my ... I am sure that I can learn it, because I am sure I can learn it. It just will take longer and when you don't feel so completely discouraged about it ... When you do feel that you do have shot to understand it and learn it, for me at least it really raises my attitude towards it. It doesn't feel like it's this hopeless thing that I just have to suffer through. It is kind-of just a hill you climb, right?



Through the service-learning project Mason has taken on the perspective that learning mathematics is no longer a hopeless endeavor. It is hard but it is worth it.

*Summary of Mathematics being Worthwhile*

In determining if the students in the case study found mathematics to be worthwhile, one of the hardest distinctions to make was if they were expressing the worthwhileness of the experience in terms of the mathematics involved or purely in terms of the service. In other words, could students find value and worth in the service but still not see the mathematics as worthwhile? As addressed previously, ideally the answer to this question should be no for any well-designed service-learning project. A well-designed service-learning project necessarily involves integrating the content of the course into the service being performed. So then, if a student says that they found the service valuable, that service involved performing mathematics. In this study, while some students were initially drawn to the service-learning project because they found the concept of service in general as worthwhile, by the end of the project each student was able to articulate that the mathematics involved in the project was worth the effort spent to learn and apply it.

*Summary of Productive Disposition*

Each student in the case study was able to articulate, in their own unique way, their understanding of mathematics as sensible, useful, and worthwhile. Each student in the case study can be said to have increased in his or her productive disposition towards mathematics and each student tied that increase to their involvement in the service-learning project. This result will be explored further in the discussion of the results in Chapter 5.

## **Additional Themes**

In addition to seeing each student develop a more productive disposition towards mathematics, several other key additional themes arose in the open coding of student interviews and reflection journals. These themes included student reference to the relational significance of the project and their development of empathy (Hunter, 2017), grit (Duckworth, 2016), and growth mindset (Dweck, 2006). These themes won't be developed extensively in this report but rather the intention is to clearly tie these themes to service-learning, thereby laying the groundwork for future studies.

### *Relational (Empathy)*

There exists a growing body of research on empathy in education (Hunter, 2017). Empathy is the ability to look at a situation from another point of view. It is the basis of caring relationships and allows students to connect and understand those who may be different from themselves (Hunter, 2017). While not the focus of this study, it was significant to note how often students referenced the value of relationships and understanding other people's stories during the course of this project. These comments lay some groundwork for future studies in connecting service-learning with developing empathy.

Tabitha indicated in her initial interview that she saw the purpose of the project of helping someone and understanding their situation in life through the use of statistics.

Tabitha: I think the practical purpose of this experiment is to learn how to use math practically. Use it to actually help someone in real life and learn how to fix situations or improve situations using statistics.

Tabitha also really connected with some of the resources that the students were required to read during the course of the project as part of their reflection journals; resources that provided more information about homelessness in the city.

Tabitha: One thing that really stuck out to me was when the article talked about the higher safety risk for women on the streets. And even though many organizations are attempting to help homeless people there is an overarching lack of resources. This applies to our project because that is what [the partner organization] is creating a safe environment and community in which homeless people can battle their addictions and not have the safety risks, such as auto/pedestrian accidents, that they experience living on the streets.

Tabitha indicates developing empathy not only for the homeless but also for the partner organization and the work they do through the service-learning project.

Ava made it clear at the beginning of her journal entries the importance she placed on empathy during the course of the service-learning project:

Ava: We should also not ignore the more personal side of this project in learning about people whose life experiences have been very different from our own.

This understanding of the importance on developing empathy was a key entry point for Ava gaining interest in the project.

Ava: I like that they (the partner organization) try to build relationships with homeless people rather than just pass out jackets and food.... I definitely thought it was interesting when the presenters came

and talked to us about it. I was really glad that they were bringing in a side that wasn't just like, we're just measuring statistics. They brought in the side that was also like, this is a service project as well, and I like that it's had both sides of that.

The connection that Ava had to the project through developing empathy for both the homeless and mission of the partner organization aided her in making a connection with the course content.

Ava: I think it's really cool to be a part of proving that it (the specific mission of the partner organization) helps and if [the partner organization] can use this data in some way to show people that this is more the approach that we need to be taking towards fixing homelessness. I think that would be really cool, to have been a part of that.

In her final interview, Ava summarizes the benefits of service-learning:

Ava: I think it's good because it does allow you to get some real world perspective and at the same time it's not just something that's a useless real world perspective, like you are getting that perspective and you're also contributing something to people who can use that to do something good with it.

The “good” that Ava saw in the project was benefiting the homeless and the partner organization for which she had developed empathy.

John, who already had a very positive view of mathematics coming into the project, was pushed to an even more nuanced view of how mathematics can be applied in

a service context because of his empathy – wanting to learn more about the people that he would be serving and their stories.

John: A project without service, it would be fine, but I feel like it wouldn't be as fulfilling because we get to work with these homeless people and see what they're like. Yeah, I would say that I would feel more fulfilled by the service project, I don't know, because we're actually benefiting people.

For John, the motivation is not just about serving the homeless but doing so in a very personal and relational way:

John: It's not hard for someone to donate money to charity or organizations, but they truly build relationships and care for the people. It's also difficult for someone to continually help the homeless instead of it being a one-time thing.

Even with this understanding going into the project, John still expressed the significant impact that the survey portion of the project had on him.

John: My expectations were completely thrown off when the survey was taken. [the person we interviewed] talked to us for two hours when my trial runs (for the survey) only took about fifteen to twenty minutes. I wasn't really bothered by it and was actually interested in his story, but it was funny how we were the first ones to start and the last ones to finish.... [The person who we interviewed] reflected the stories of thousands of homeless people in my mind

who had a messed up family life and showed why many of these people are just looking for care and love from others.

As was discussed above, John derived an increased understanding and appreciation of statistics through the service-learning project, but he also indicated the relational insights that he gained as well:

John: I'd also say [the service-learning project] helped learn in a general sense of the homeless and how your situation can affect who you are as a person, and listening to this person talk for two hours was just very eye opening.

Not only did John get a lot out of the project from the side of people that he was serving through the service-project, but also from the collaborative side of the project in the classroom. In other words, relationships weren't just developed with those in the community, but amongst students as well.

John: The collaborative kind of aspect of the project was very helpful because it'll allow us to all work on it together so we don't forget something or make a mistake somewhere in there. I think a really key point to our success, because we all worked together to accomplish a goal. I feel like the collaborative effort was definitely a key part of our success. I feel like as far as community service, the community service aspect is great, but I would also stress the interactive aspect of it.

In the end, John saw an increase in his productive disposition through the service-project in large part due to the relational side of the project and the empathy that was involved.

John: I could write [stats] on my paper all I want but I don't know what it actually looks like in the real world. I feel like doing it for the community makes it even more special because it makes you feel good inside that you did something for someone else and your helping these people that are less fortunate than you obviously. I feel like the interactive side of it is very important, and is needed as opposed to just staying in the classroom and just learning the material.

Charlotte also expressed the benefits of getting to know the partner organization and the homeless people that they serve. From her initial interview:

Charlotte: I like how this project we're able to actually make a difference and serve someone instead of doing it for our own benefit. I was excited.... Then, we were able to actually meet the owners (of the partner organization). They were actually able to come in our class, so we had a firsthand experience of what it was about.

Like Tabitha above, Charlotte clearly noted developing empathy over the course of the project through her reflective journal entries and the material she was required to interact with. Charlotte noted the significance in the mission of the partner organization and the impact that her reading of *Chasing the Scream* (Hari, 2015) had on her:

Charlotte: They not only feed them but they form relationships with them and walk alongside them in the long journey to recovery... [drug addiction and homelessness] is not a chemical addiction in the brain but a longing to be loved and known. Homeless people use

drugs as a way to keep themselves busy and as a distraction from their loneliness.

In referencing another reading about interacting with the homeless:

Charlotte: I was moved by the words she said about the homeless man, “his joy was infectious.” That struck me because we always think of homeless people as hopeless and sad. Homeless people do feel the weight of judgment. We need to treat them like they have a story and a name. Her line “community connects us with the presence of God” connects with [the partner organization’s] mission. They want to provide community to the homeless.

In the end, Charlotte noted the impact of having empathy for the stories and experiences of other people:

Charlotte: I think I learned that everyone has a story and everyone's story matters.... It's humbling to hear someone else's story...

Above it was noted that John came into the project with a very positive attitude towards mathematics and the relational side of the project drew him in further. For Mason, he began the year in the exact opposite situation with a very negative attitude towards mathematics, but in a similar way the personal and relational side of the project served as a big motivating factor for him.

Mason: I love to see practical applications of things. I think us being able to use stats and, I guess, our status in our situation in life to be able to help other people. I love doing that. I love helping people. I love investing in other people; like building relationships. Not so much



with the math part. I think that's an added benefit that we can help a broader scale of people, but I was excited.... I know that I know have a heart for people that are homeless and struggling. If we put that together, I really, really, really think that we can do a great thing. I'm not just saying that. I think this can be hugely beneficial.

As the project unfolded, Mason referenced the benefits he gained from interacting with the partner organization and guest speakers.

Mason: [The guest speaker] answered our questions so well and really helped me to further understand what's going on with the people we will be dealing with.

When reflecting on the experience of giving the survey:

Mason: I have to say it was pretty much what I expected. The difference was the story that we heard from (the person we interviewed). He was incredible, with a powerful story behind him. To me, that's what stood out the most. As of rewarding experiences, the story and relationship with (the person we interviewed) was the best.... As for the relevance of the class applied to [the partner organization], I can see it, but I think the most important thing was the connections with the people surveyed.

Mason summarized his experience in his final interview:

Mason: Something that I think was really important, at least for me personally, is being able to go and feel like you're understanding what's going on in the community through the survey.... Again, for

me, I thought it was a lot more about people than it was about stats. I wanted to try to help people and build a relationship with people. I wanted to learn, what really can make people homeless or what really destroys biases that we have towards homeless people? They're all drug addicts, or they're all panhandlers and they're all ... and that kind-of stuff is a lot of stigma that we have towards them.... Now [my survey partner] and I have that experience shared together. We sat down and had a conversation with somebody that was missing an arm and found out a lot about what was going on with him and we have talked about it. It was a really cool experience.

Every student in the case study indicated either the development of empathy on their part or the role it played in motivating them to do well on the project. It is worth exploring further the specific role empathy plays in developing productive dispositions in students in mathematics.

### *Grit*

While not the focus of this study, grit (passion and perseverance for long-term goals) is a major focus of current educational research (Duckworth, 2016) and showed up often in student responses to interview questions or journal prompts. While the students didn't mention the term "grit" specifically, they did speak often about persevering (or not) through struggles on the project to reach their desired outcome. A few notable instances are summarized below.

Tabitha, at the beginning of the year mentioned her specific lack of grit when it came to mathematics:

Tabitha: Well, if I have a problem then I will solve it but I would rather someone else solve it for me. If there's no solution out there and there's a problem, then I'll solve it. But, if there is then I would prefer just not to use my limited math skills and limited energy.

Tabitha mentions that while she will put in work and effort and perseverance, if there is a “quick out” in mathematics by finding the solution another way, then she prefers to take it. While this perspective hadn’t changed completely by the end of the service-learning project, it is worth noting a comment Tabitha made in her end-of-the-year interview.

Tabitha: I am sure I can learn mathematics. I'm not prohibited in any way, but I'm not naturally inclined to be good at math. It takes me a lot more time and effort to be good at it.

While Tabitha never gave any explicit indication that she developed perseverance through the project, she at least offers the recognition that she has the capability.

Ava never had any mentions of grit or perseverance. At the beginning of the year in both the initial interview and his journal, John, who was a very successful math student, mentioned where he struggles in terms of grit and perseverance.

John: Yeah, I struggle with working on problems, and if I don't get the right answer immediately, usually I'm pretty frustrated because, I don't know, I feel like I'm smart enough to get the right answer most of the time. I'm not used to struggling with something, and when I do, I'm really frustrated.

In his journal, John expanded on a question from the FSMAS survey that related to how well he stuck with problems that he couldn't immediately solve:

John: When a math problem arises that I can't immediately solve, I stick with it until I have the solution (responded 3-neutral): This is probably one of my weaknesses for studying math. Math normally comes easy to me, so when there is a problem that stumps me, I become frustrated and quickly ask for help. I have worked to become better at this, and I now usually try to figure the problem out on my own for a little bit at least. I still need to find the balance from being stubborn and not wanting help versus going straight to someone when I don't find a solution.

Here, John expresses a desire to grow in his ability to persevere through a problem. It can be argued that he began to find some of that balance through the service-learning project.

In his journal towards the end of the year John noted:

John: I enjoyed coming up with the conclusions at the end that actually made sense and benefitted [the partner organization]. It was cool to see the fruits of our labor come to so many different conclusions. At the same time, performing these tests ended up being painstakingly long and tedious. However, it was worth it to me in the end because we finally reached many conclusions from the data we collected and actually contributed to a great organization by coming up with real answers in a real-life situation.

In the end, John had to work through frustrating situations on the project that didn't have an exact answer and he mentions how beneficial it was to persevere and see the fruits of his labor.

Charlotte, like Tabitha above, was prompted by a question on the FSMAS survey to reveal at the beginning of the year her lack of grit in mathematics.

Charlotte: I think those responses show how lazy I am, how undedicated I am to math maybe necessarily. I guess in life ... This can be compared to life. If some problem happens I'd rather find the easy way out than actually like, working through it. If someone would just give me the answer than that's what makes life so much more easier. Even though realistically that's not how you're supposed to do it, but in my lazy world I'd rather just have someone give it to me.

Charlotte recognizes that this is not the most helpful approach to mathematics even though it is the approach she had coming in at the beginning of the year.

Charlotte: I know that that ... someone giving the answer to me will not help me in any way because then I won't know how to do any of the problems.... Even Though someone giving me the answer is not beneficial in the long run, I am lazy when it comes to math and would rather move on then spend hours on the same problem.

Charlotte also specified why she had this lack of perseverance in mathematics specifically.

Charlotte: Math is not easy and can require several steps to one half of the problem.... Math makes me feel impatient because there is only

one right answer and so it takes a long time to find that one answer. Unlike writing essays, math is very precise and if you mess up on one simple step, you ruin the whole problem.

Through the service-learning project, Charlotte was able to express a very positive attitude towards persevering in mathematics at the end of the year.

Charlotte: This year I have worked harder in math than I ever have. I have really tried to put effort into my grades and try my best. I used to do as little work as possible but now I realize that math is very important and requires a lot more effort than I have ever put into it. It's important to put time and energy in math because you will get the best results if you do.

Mason presented a very similar attitude towards perseverance in mathematics as Tabitha and Charlotte at the beginning of the year. From his initial interview:

Mason: Math, it frustrates me. The amount of time I put in to math is a lot, a lot more than I do to any of my other classes. It doesn't reflect in grades.... When you come to the waste of time aspect of it, I feel like I would struggle whether I studied or not, but the part of me ... I still study because I want to do well and I still think there's that chance that I'll do well, but the amount of time I put in and not seeing results, it's frustrating, it's difficult, and it seems like I'm kind of wasting it.

By the end of the year, Mason still communicates struggling through the concepts of mathematics, but at the same time he demonstrates a greater resilience to work through

problems to reach a result that is meaningful in the context of the service-learning project. At the end of the year when asked to reflect on what was most challenging about the project:

Mason: Obviously, the challenging parts were the stats parts. I had to work pretty hard in stats this year. Nothing against stats, I'm just not very good at it. I just have to dig in when I really want to learn something. I have to spend a lot of time on it. In some ways, I felt like having to use stats to figure out what we learned was frustrating, but I thought it was good too. The benefits were, I was actually seeing, no, this was a real life thing. You're going to use stats in really life. You're going to be able to actually benefit people. You're going to benefit yourself.

Much like the student responses relating to empathy above, the students did not go into great detail on the development of their perseverance in mathematics (as this was not the primary focus of the questions they were asked in the study). However, the students discussed their perseverance in enough unprompted situations to demonstrate that it may be worth exploring how service-learning might lead to the development of grit.

### *Mindset*

Like the concepts of empathy and grit above, mindset was not a focus of this study but was discussed often enough by students in interviews and journal entries that it bears mentioning here. There are two types of mindsets, fixed and growth. In a fixed mindset, people believe their basic qualities, like their intelligence or talent, are simply

fixed traits. In a growth mindset, people believe that their most basic abilities can be developed through dedication and hard work (Duckworth, 2006; Dweck, 2006).

Tabitha mentioned often at the beginning of the year how she just wasn't a "math person," exhibiting a very fixed mindset. This showed up several times throughout her final interview of the year. As mentioned above, Tabitha was an interesting case where she came into the year with a very positive attitude towards mathematics and her ability to learn it, but that was built on a misconception of mathematics as algorithmic classroom learning. When presented with the experience of creatively applying mathematics to real-life, Tabitha came to the realization that she might not be as good at math as she thought she was. When asked why she thinks she might have struggled on the project:

Tabitha:        Maybe but I think I'm also, like I struggle with math in general, so I think like it probably was easier for some people.... I learned I am not a statistics person and so I think at the beginning of the year, I think I understood the material better whereas now I'm just barely like, I don't understand what we've learned recently, so I'm confused.... Yeah, I mean I've never been a math person but usually I can like understand basic concepts, but... I don't think I really understood.... to analyze like data without having a problem set up, just kind of really made me confused.

While demonstrating a very fixed mindset, Tabitha did make several mentions during the project of recognizing that she could grow in her ability to do mathematics if she was to put in the effort.



Tabitha: I am sure I can learn mathematics. I'm not prohibited in any way, but I'm not naturally inclined to be good at math. It takes me a lot more time and effort to be good at it.... I am sure that I can learn math if I put enormous amounts of time into it.

Finally, Tabitha mentions potentially growing in her ability to learn mathematics through the service-learning project. After the service project, when asked why she should value her math education:

Tabitha: I think that we should value our math education because it is so applicable to any job we might have. It helps with problem solving and I am not a math person, as my test grades show I struggle, however I think trying to teach your brain to think in ways that does not come naturally is always beneficial.

Like Tabitha, Ava also frequently mentioned how she was not a “math person,” demonstrating a fixed mindset approach to mathematics.

Ava: Well, I've just never been a “math person,” I guess. Literally, ever since second grade, every single year, math has been my worst class and the class I've had to work the hardest in just to make a decent grade in comparison to the rest of my grades. Even though I know math is important and I definitely am glad that I've taken it, it's always been my hardest class and I don't enjoy math.

When asked at the end of the project if she felt like her attitude towards mathematics had changed at all:

Ava: Honestly, I don't know if my attitude towards math has changed positively or just changed a little bit, just maybe more towards the type of math that I don't dislike as much, but I'm just never going to be a person that enjoys math. I just never have been that, I never will be.

Interviewer: Okay. Why do you say that?

Ava: I don't know why people are ... Some people are born just better at some things and other people are born better at other things I guess. I've just always been more of a person that's better at humanities and that likes that more.

Ava is an interesting case because she clearly demonstrated growth in her productive disposition but did not seem to demonstrate any change of her mindset.

While Ava did not communicate any indication of developing a growth mindset, John seems to display nothing but a growth mindset in mathematics. From his initial interview, John not only portrays perseverance when he struggles through a problem, but he recognizes his ability to grow in terms of learning mathematics (even though he came into the year already being quite successful at mathematics).

John: Yeah, I struggle with working on problems, and if I don't get the right answer immediately, usually I'm pretty frustrated because, I don't know, I feel like I'm smart enough to get the right answer most of the time. I'm not used to struggling with something, and when I do, I'm really frustrated. I don't know, I try to work on that by just not being frustrated and trying different ways to solve the

problem. I think I've gotten better on it this year for sure because pre-cal, I've struggled a bit in that class, but in the end, I've done well on all my tests and assessments by asking the teacher for help and asking other people for help, usually.

John not only explains his ability to improve and grow in his problem solving abilities, he also shows growth in his understanding of what service is and how it can be integrated in the classroom.

John: I would still define a ministerium (service) as when a group comes together to selflessly benefit others. However, my view has somewhat changed on what this looks like. Usually when you think of statistics you think of doing labor intensive work to assist someone who is less fortunate than you. For this project we didn't do any manual labor, but still helped the people at [the partner organization] and the previously homeless people themselves. These people got a chance to talk to someone face to face and express their feelings, which brightened their day (at least for my person it did). So the definition remains similar to what I had previously, but this project changed my perspective on how ministerium is able to manifest itself.

Charlotte began the year in the same way as Ava and Tabitha as not seeing herself as a "math person" and communicating a very fixed mindset.

Charlotte: I feel like you have to have like, a mathematical brain to understand a lot of math things.

However, unlike Tabitha and Ava, over the course of the year Charlotte very clearly articulated a growth mindset in mathematics. It is worth considering (in a future study) if the significant increase in Charlottes FSMAS scores between the beginning and end of the year are at all correlated to her growth mindset. Starting in her initial interview Charlotte noted:

Charlotte: I know that I can do it in the end. It's just the process of me actually doing the math problems, if that makes sense.

In her journal over the course of the year Charlotte noted:

Charlotte: I think we should value everything about our math education. I think it can be extremely helpful in everyday uses. I think my opinion has changed because I've grown to see math in a new and different way.

Charlotte also notes the work that she has put into math this year (that she hadn't in the past), believing that the work that she put in would have an impact on her ability to grow to understand mathematics better.

Charlotte: This year I have worked harder in math than I ever have. I have really tried to put effort into my grades and try my best. I used to do as little work as possible but now I realize that math is very important and requires a lot more effort than I have ever put into it. It's important to put time and energy in math because you will get the best results if you do.

Like John, Charlotte also experienced growth in her understanding of service and its relationship to what she is learning in the classroom.

Charlotte: I still think math is very valuable even more so after the project is over. I also think ministerium (service) is a way for us to serve the community with gifts and talents. Now, I know I can serve the community with mathematics! That is something I would have never thought of until this year.

In her final interview, Charlotte attributes this growth to the engaging nature of the service-learning project:

Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun. I think because before I just saw math as numbers in a classroom, and taking notes and equations, but now I can see math in every day activities and uses.

Mason was very similar to Charlotte in that they both indicated at the beginning of the year a very fixed mindset, which then seemed to change to a growth mindset as the year progressed. This is interesting to note as both Charlotte and Mason saw drastic improvements on their FSMAS scores at the end of the year. It would be worth exploring further in another study the relationship between growth mindset and the development of a productive disposition. In his initial interview Mason noted:

Mason: Yeah, I've never been great at math. It's never come very easily to me.

When asked to respond in his journal to the FSMAS survey he took at the beginning of the year, Mason had this to offer about his fixed mindset:

Mason: It would kill me to take any more math courses. I'm not very good at it, and even though I study, I still don't quite get it. I ranked this a 1 simply because I'm a humanities kid and like working on stuff that requires critical thought and insight.... I wonder if I really can learn mathematics. I've never really been able to do it well, and that meant I had to work harder than the other kids who were naturally gifted at math. I hang out with a pretty smart group of kids who really seem to do little to no work in math, and the fact that I still don't "get" stuff gets pretty annoying. Maybe I can learn it, but it will just be really difficult.

Later in his journal, Mason begins to indicate more of a growth mindset towards mathematics though his work on the project.

Mason: I am sure that I can learn this. Math was hard, but when I dug in, I could actually learn what was being taught, and I even got a couple A's here and there! That being said, I don't think it's my strength, and I don't think I'm good at math. Its hard work, but I still think I can get there.

In his final interview, Mason also discussed the change that he had undergone when looking at his own ability to do mathematics.

Mason: I had to work pretty hard in stats this year. Nothing against stats, I'm just not very good at it. I just have to dig in when I really want

to learn something. I have to spend a lot of time on it. In some ways, I felt like having to use stats to figure out what we learned was frustrating, but I thought it was good too. The benefits were, I was actually seeing, no, this was a real life thing. You're going to use stats in really life. You're going to be able to actually benefit people. You're going to benefit yourself.

Mason also tied this growth specifically to the service-learning project.

Mason: Service is awesome. Being able to see the benefits of ... You are actually impacting these people's lives. Not off of a 'look what I can do,' but look at that. We can actually make a difference in our community, and we can use a special set of skills to make math fun. Which for me, math has never been fun. Since I've been a little kid, math has never been fun. It's always been hard for me. It's always been a task for me to sit down and do my math homework. This was actually enjoyable. It was cool to see.... I just thought it was a lot of fun and I thought it really changed my view of stats. We started doing this and it really picked up at a time when I was really struggling in it. It really made me think, it's not so bad. I can do this. I can do this.

Finally, when asked to discuss if he felt that his attitude towards mathematics had become more positive over the course of the year:

Mason: Yeah, definitely, much more positive. It was hard, don't get me wrong and I'm not saying I'm no good at math thing didn't change,

but I do think ... I should've changed my ... I am sure that I can learn it, because I am sure I can learn it. It just will take longer and when you don't feel so completely discouraged about it ... When you do feel that you do have shot to understand it and learn it, for me at least it really raises my attitude towards it. It doesn't feel like it's this hopeless thing that I just have to suffer through. It is kind-of just a hill you climb, right?

At the end of the year, Mason is clearly articulating a growth mindset in mathematics – that he has the ability to learn it and be successful and that his math education is no longer a hopeless endeavor.



## **CHAPTER VII: RESULTS: SUMMARY OF FINDINGS IN THE CONTEXT OF RESEARCH QUESTIONS**

Below, Table 9 summarizes the research questions of this study and the manner in which data was collected and analyzed to assess the outcomes of this project.

Table 9: Summary of Research Questions and Methods of Measurement

<b>Research Question</b>	<b>Variable</b>	<b>Indicators</b>	<b>Measurement</b>
1. To what extent does service-learning impact the cultivation of math affections among students?	Development of Productive Disposition tied directly to involvement in community experience	<ul style="list-style-type: none"> <li>• Role of community experience in learning</li> <li>• Role of community experience in engagement</li> <li>• Changes in perspective on course content</li> </ul>	Interviews Surveys Reflection Journals
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?	Understanding course content (Sensible)	<ul style="list-style-type: none"> <li>• Role of community experience in understanding course content</li> <li>• Perceived relevance of community experience to course content</li> </ul>	Interviews Surveys Reflection Journals Observed interactions with students and instructor
	Applying course content (Useful)	<ul style="list-style-type: none"> <li>• Role of community experience in applying course content</li> <li>• Recognition of practical application of course content</li> </ul>	Interviews Surveys Reflection Journals Observed interactions with community partner
	Valuing course content (Worthwhile)	<ul style="list-style-type: none"> <li>• Role of community experience in producing a rewarding sense of work committed to course content</li> <li>• Recognition of community experience to sufficiently important to justify effort spent</li> </ul>	Interviews Surveys Reflection Journals
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on mathematics education?	Cost/Benefit analysis on the feasibility of implementing community experience	<ul style="list-style-type: none"> <li>• Recommendation to utilize community experience in other courses</li> <li>• Valuing time spent on community experience over against traditional methods of learning</li> <li>• Drawbacks of community experience</li> </ul>	Interviews Surveys

**Research Question 1: To what extent does service-learning impact the cultivation of mathematical affections among students?**

In one sense this research question can be answered by looking holistically at the case studies above to affirm that clearly service-learning has an affective impact on students as they learn mathematics. At an individual level it is worth noting that every student in the case study made an explicit reference to the service-learning project as indicating some change or impact that occurred for them at an affective level. Below is a summary of what each student said in his or her own words. For reference, it is useful to re-examine Krathwohl's affective domain of learning, summarized in table 10.

Table 10: Krathwohl's Affective Domain of Learning and Corresponding Research Organization

		Krathwohl's Affective Domain	Summary of domain category	Associated Verbs for Student Learning Objectives	This paper groups research that focuses on:
Virtues Practiced by Students		Characterizing	individual has a value system that has controlled his or her behavior for a sufficiently long time for him or her to develop a characteristic "life-style" – thus the behavior is pervasive, consistent, and predictable	Revise, require, rate, avoid, resist, manage, resolve	allowing values to inform practices
		Organizing	bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system	Discuss, theorize, formulate, balance, prioritize	
Values Instilled in Students	Behaviors from simple to complex	Valuing	the worth or value a student attaches to a particular object, phenomenon, or behavior	Measure proficiency, subsidize, support, debate	developing an attitude toward a particular subject, in this case mathematics
		Responding	active participation on the part of the student	Comply, follow, commend, volunteer, acclaim, engage in	
		Receiving	student's willingness to attend to particular phenomena of stimuli	Differentiate, accept, listen for, respond to	

When Tabitha was asked if she would recommend doing the service-learning project for other classes:

Tabitha: I would recommend that they do so because it's a really cool concept.... I think learning to practically apply what your learning in the classroom is important.

Elsewhere in her journal, when asked at the end of the year to reflect back on the experience of the project:

Tabitha: As the semester has progressed I have slowly understood more and more about what we are doing in this project. Honestly, at the beginning I really didn't like it, but I think the group work and the articles helped get us invested in the project. It is also fun to mix school work with community work. And even though I struggle with statistics I think it is helpful to see the practical use of math in real life situations, even if they are some what [sic] simulated. One of my favorite parts of the project has been reading the different articles specifically the news articles. It's exciting to see how what we are doing applies to current events.

Words Tabitha uses in reference to her experience on the project: cool, important, invested, fun, exciting. "Cool," from the teenage vernacular, in this context referencing a "cool concept," can probably be best understood as meaning "admirable." By definition, to be "admirable" is to inspire approval, reverence, or affection. "Cool," "fun," and "exciting" are all verbal indicators of Tabitha being at the *receiving* stage of Krathwohl's taxonomy, in that Tabitha is demonstrating a willingness to attend to a particular stimuli, in this case the service-learning project. By Tabitha indicating that she (and her classmates) are "invested" in the project she is indicating that she is at the *responding* stage, communicating an active participation on her part. And finally, Tabitha's reference to the project as "important" indicates the worth that Tabitha has attached to the service-learning project, thereby reaching the *valuing* stage.

Before leaving Tabitha's case, it is important to remember that Tabitha also expressed having her affections impacted in a negative way:

Tabitha: Yeah, I think because we've never had to practically apply [math] before and because it's like a completely new concept for us. I think I just really, it made me uneasy to know that like, I couldn't, like that that was extremely difficult for me to know that like I can learn concepts in the classroom but when it comes to practically applying it, I was kind of, not able.

Tabitha is clearly indicating what she is used to in math class and how that experience contrasts with her experience of the service-learning project. It can be argued that this is a beneficial change and struggle for Tabitha to go through. As discussed previously, Gomez-Chacon and Haines (2008) offer examples of a positive attitude toward a false perception of math being classified as a negative attitude. In other words, seeing math positively because the student views it as a set of procedures to be memorized and they feel capable enough of doing that, could legitimately be understood as a negative attitude toward mathematics. In Tabitha's case, it could be understood that she is communicating the uneasiness of moving away from a false view of mathematics. Regardless, it is clear from her description that Tabitha is at the *organizing* stage of Krathwohl's taxonomy: bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system. While Tabitha doesn't fully resolve the conflict by the end of the year, it is clear that the project was working to impact her perception of mathematics at an affective level.

When Ava was asked if she found the service-learning project beneficial she noted:

Ava: I definitely like the idea of having a service project that goes with what you're learning I think when you can apply what you're learning in that type of way. It just makes it more real world kind of.... I think the most rewarding thing was to be able to see the presentation that [classmates] did and with the [partner organization] people there was cool to see the results to be presented to them and they can actually use this.... I think [service-learning is] good because it does allow you to get some real world perspective and at the same time it's not just something that's a useless real world perspective, like you are getting that perspective and you're also contributing something to people who can use that to do something good with it.... This project has meaning and it has a clear use, so we're not just going out and measuring something random.

Ava refers to the project as “rewarding,” “cool,” “good,” and having “meaning.” Like Tabitha above, the term “cool” is a clear indicator of Ava reaching the *receiving* stage. “Rewarding” is an indication of an active involvement on Ava’s part indicating her reaching the *responding* stage, and referring to the project as “good” and “having meaning” clearly indicate Ava reaching the *valuing* stage. At the end of the year when Ava was presented with her FSMAS scores that indicated a positive change towards mathematics and asked to comment:

Ava: Honestly, I don't know if my attitude towards math has changed positively or just changed a little bit, just maybe more towards the type of math that I don't dislike as much, but I'm just never going to be a person that enjoys math.

Ava seems to lump service-learning in mathematics as a “type of math I don’t dislike as much.” While Ava has certainly indicated finding value in service-learning and describe more positively than her previous experience of math courses, her experience over the course of one school year was not enough to completely overcome the culmination of her experiences in prior math classes. It can be argued that this statement reveals Ava reaching the *organizing* stage where her perception of not being a “math person” and disliking math was now coming into conflict with her experience on the project, thereby leading to her need to clarify about the “type of math I don’t dislike as much.” Ava’s follow up statement that “I’m just never going to be a person that enjoys math,” indicates that this project didn’t push her all the way to the *characterizing* stage.

In addition to Ava’s indication of which affective stages she was reaching during the project, she clearly discusses *how* she reached those stages (both during the project and prior to the project). Prior to the project Ava gave a clear indication of how her characterizing of mathematics as something that she understood on principle as important though she doesn’t feel successful at it:

Interviewer: The last thing is what you said in your journal entry of saying what you said about working harder but not enjoying it as much, but then at the same time recognizing that, to be considered an educated person you have to have math, and so seeing value in

that. I was wondering if you can expand on that last line in your journal entry of agreeing with that statement on principal, of math being worthwhile.

Ava: Yeah. I think it's just been drilled into me through [this school], because [this school] focuses so much on having a strong core curriculum and saying you need to understand all disciplines to be a well educated person even if you don't like this one subject and even if you don't want to do that in college or in your career, it's still important that you understand it at least at a basic level. I think I've come to value that and understand why that is an important thing.

Ava credits the repetitive practices, routines, and liturgies of the school as forming her characterization of mathematics. During the project itself Ava clearly mentions finding value in the service aspect of the project, but she also indicated how the regular practices (liturgies) of the classroom that changed in order to implement the project were equally impactful on her appreciation of the project:

Ava: Well we definitely talked more in this math class than another other math class about reading assignments and having a journal entry due every week, like reinforced while we were learning about the tests that we were going to be using the journal entries were requiring you to think beyond that and think about homelessness and think about the specific facets of [the partner



organization] that maybe we wouldn't be talking about in a regular stats class.

Ava certainly gave indications of service-learning, and the changing habits of the classroom that resulted from instituting the service-learning project, as impacting her appreciation of mathematics at some level. Tabitha also mentioned the impact of the practice of reading articles as well.

In discussing the impact of the service-learning project, John recalled the impact of the service-learning project from his freshmen year as well:

John: Just doing the project and the gazebo project, from freshman year, definitely aided my learning. I feel like I going to remember how to do some of this statistical stuff and I feel like I'm definitely going to remember how to do this project, like what we did during this project because of [the partner organization].... I could write [stats] on my paper all I want but I don't know what it actually looks like in the real world. I feel like doing it for the community makes it even more special because it makes you feel good inside that you did something for someone else and your helping these people that are less fortunate than you obviously. I feel like the interactive side of it is very important, and is needed as opposed to just staying in the classroom and just learning the material.

John came into the project with references to mathematics leaving him “fulfilled” to find the correct answer to a difficult problem. Here he references the project as making those mathematical experiences “more special,” indicating reaching the *valuing* stage. John

also explicitly mentions how the project impacted his understanding of ministerium (service) and how mathematics could be applied in a service context.

John: This project changed my perspective on how ministerium is able to manifest itself.

This changing of perspective as it relates to how mathematics could be involved in a service context indicates that John has at the very least reached the *organizing* stage, if not the *characterizing* stage.

Charlotte indicating a significant change in her perspective of mathematics through the course of the project and she attributed that change directly to the service-learning project:

Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun.

When asked at the end of the year if she thought it was reasonable to say that her attitude towards mathematics had become more positive, Charlotte noted:

Charlotte: Yes, I do feel like my attitude in math has become more positive because ... I really think it's because of the service-learning project and because ... Math is easier to understand when it's used outside of the classroom, and it's more relatable to me when I'm using it in real life situations, so I think just this realization that I can use

math in every day activities helps me see it more positively

because then I realize it's more useful, and it actually does matter.

Charlotte references the project as “exciting” and “engaging” and as something that “actually does matter.” This gives a clear indication of Charlotte reaching the *valuing* stage. In both comments above Charlotte notes the change that has occurred in her perspective from the beginning of the year until the end, indicating that she has also reached the *organizing* stage where she is resolving conflicts between values, and beginning the building of an internally consistent value system. Like John, Charlotte also recalls the lasting impact of her prior experience of being involved in service-learning during her freshmen year:

Charlotte: Before, my answers are kind of the same, but thinking math is a waste of time, because before, once again, I just thought that math didn't really apply to anything besides math classes, because I never thought I'd be using sine and cosine in the real world or any of geometry in the real world, but now, through our service project and through the geometry project of creating a little tent thing for the RVs, I realized that math can be used in more ways than I thought. They can be used in the real world and not just in a classroom.

Charlotte is offering increased evidence of the long-lasting impact that the change of routines/experiences/liturgies of the mathematics classroom can have on a student.

Charlotte is referencing changes in her perspective from three years ago indicating that perhaps she is entering the *characterizing* stage to some extent.

Despite the overwhelmingly negative description Mason had for schooling and his experience of the math classroom, even during his initial interviews he hinted at how his curiosity had been piqued by the introduction of a service-learning project in statistics.

Mason: Yeah, for me [the service-learning project] has made stats a lot more enjoyable; math a lot more enjoyable overall. Knowing that there is like practical application for what we're learning. I really enjoyed that.

Like the previous cases Mason went on to clarify that it was not just the practical application of the material but specifically the service aspect of that application that impacted him.

Mason: That was really fun to see something that I've traditionally really disliked a lot actually bring me some enjoyment and happiness to see we could use that to really make people's lives better and help get them to a better situation.

Mason goes so far as to attribute to the project the potential of altering his fixed mindset to more of a growth mindset.

Mason: I just thought it was a lot of fun and I thought it really changed my view of stats. We started doing this and it really picked up at a time when I was really struggling in it. It really made me think, it's not so bad. I can do this. I can do this.

When asked at the end of the year about changes in his FSMAS survey responses:

Interviewer: Looking at number 11 [on the FSMAS survey], "I study math because I know how useful it is." In the fall, you said, two,

somewhat untrue and in the spring, a four, somewhat true. I wonder if you could just talk about that.

Mason: I entirely attribute that to stats, just the class itself. It felt a lot more practical and, as well as, with our service-learning project. I saw a lot of real things. Real things were happening there. It really showed me, this isn't some head in the clouds thing if you're not going to be an engineer. I saw a lot of real application to it.

Mason refers to the project as “fun” and “enjoyable.” He mentions multiple times that the project changed his perspective on mathematics, a discipline that he had previously staunchly disliked. All these comments taken together clearly place Mason at the *organizing* stage at the very least.

In summary, the question at hand is “to what extent does service-learning impact the cultivation of mathematical affections among students?” Students seem to regularly reach the *organizing* stage of Krathwohl’s affective domain: bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system. A few students, particularly the ones who had prior experience with service-learning in mathematics, could be said to have potentially reached the *characterizing* stage (though a full analysis of the characterizing stage would need to take place over more than just the course of one school year). The students also regularly attribute the method by which they reached the *organizing* stage to a change in the routine, or to use Smith’s (2009) term, a change in the “liturgies” of the mathematics class. This study then seems to give clear evidence of how service-learning engages

students at a deeply affective level and provides a venue for students to wrestle with their valuation of mathematics.

**Research Question 2: What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?**

Previously, data was displayed summarizing the results of student responses on the community based service survey at the end of the year (table 7 and figures 9, 10, and 11). The information from figures 10 (sensible), 11 (useful), and 12 (worthwhile) was combined to give every student a “productive disposition” score on a scale of 3 – 15, with 3 meaning the student responded 1 (strongly disagree) to all three topics and 15 meaning the student responded 5 (strongly agree) to all three topics.

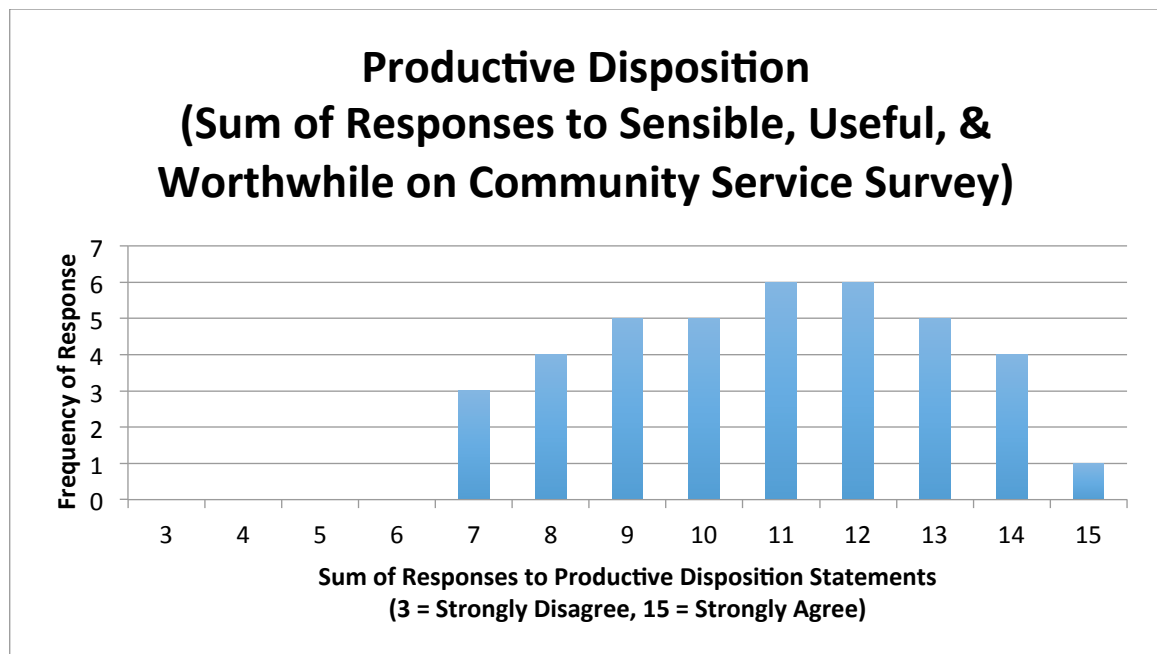


Figure 13: Summary of CBSL Survey Responses Related to Productive Disposition

The lack of responses for 3-6 are left for emphasis to clearly show that no students responded near the bottom of the productive disposition scale. Because the first score is a 7 that means no student responded below 3 for all three areas of productive disposition, so then no student responded negatively to all three areas. When testing the average score was higher than 9 against a null hypothesis of  $\mu = 9$  (neutral for all three areas), the  $t$  value is 5.14 and the  $p$ -value is 0.00000425 which is significant at any reasonable significance level. Scores starting at 10 indicate that those students had to have included a 4 response at minimum for at least one area of productive disposition. If a  $t$ -test is run against a null hypothesis of  $\mu = 10$ , the  $t$  value is 2.32 and the  $p$ -value is 0.01297, which is still significant at  $\alpha = 0.05$ .

The student interviews, field observations, and collected reflection journals were coded following the three major themes of a productive dispositions: seeing math as sensible, useful, and worthwhile. These codes initially derived from the definition of a productive disposition offered by the National Research Council (2001), followed in the vein of Jansen (2012), and were confirmed as these themes emerged through an open coding of the pilot study interviews. It is important to note that the purpose of this study is not to argue for what entails a productive disposition and the best way to define and analyze it. Rather, the focus of this study is to examine if service-learning can cultivate a productive disposition as it is currently defined by the National Research Council (2001). That is why the concepts of sensible, useful, and worthwhile were used in seeking to determine if students were developing a productive disposition through the course of the service-learning project. While in reality these terms have quite a bit of overlap in their usage (meaning students tend to see one as encompassing or necessarily following from

the other) for the purposes of coding and analyzing the student interviews and reflection journals an attempt was made to treat these terms as distinctly as possible.

The working definition of being sensible is “to be reasonable or comprehensible, rational.” The main idea for this term is that it implies mathematics is understandable, that the service-learning project has in some way aided the student in making intellectual sense of the mathematics involved. In the case study group, each student came into the class and the project with very different views on how much sense mathematics made to them. While students might make assent to math being logical and rational, when that abstract statement was made more personal to their own experience they tended to express frustrations or confusions with the mathematics they see in school. However, through the project each student was able to articulate the sensibleness of the course material. The project served to solidify each students’ understanding of the course and their ability to make sense of the mathematics involved.

The working definition of being useful is “being of practical use, serving some purpose.” The main idea for this term is that it implies mathematics has a purpose, that the service-learning project has in some way aided the student in seeing the practical applications of mathematics. While all students in the case study expressed their understandings differently, all of them indicated that the service-learning project improved their perspective on the usefulness of mathematics. A typical response at the beginning of the year was to offer an assent to math being useful, but for somebody else in some different job, in some distant future. After the project, every student was able to articulate how the math they were learning was useful in their immediate context. The usefulness of mathematics became a more personal experience.



The working definition of being worthwhile is “being rewarding, valuable to justify time or effort spent.” The main idea for this term is that it implies mathematics is worth putting time and energy into learning; mathematics offers something valuable and rewarding for everyone. In the context of this study this means that the students indicate that the mathematics involved in the service-learning project was an important task to undertake, has beneficial outcomes, and was worth the effort that was committed. In determining if the students in the case study found mathematics to be worthwhile, one of the hardest distinctions to make was if they were expressing the worthwhileness of the experience in terms of the mathematics involved or purely in terms of the service. In other words, could students find value and worth in the service but still not see the mathematics as worthwhile? As addressed previously, ideally the answer to this question should be ‘no’ for any well-designed service-learning project. A well-designed service-learning project necessarily involves integrating the content of the course into the service being performed. So then, if a student says that they found the service valuable, that service involved performing mathematics. In this study, while some students were initially drawn to the service-learning project because they found the concept of service in general as worthwhile, by the end of the project each student was able to articulate that the mathematics involved in the project was worth the effort spent to learn and apply it.

Each student in the case study was able to articulate, in their own unique way, their understanding of mathematics as sensible, useful, and worthwhile. Tabitha came into the project having a positive attitude towards mathematics but through the project she realized that the positive attitude was misplaced as she had an incorrect understanding of mathematics. Tabitha expressed discomfort in transitioning from seeing

mathematics as formulaic classroom learning to creative, real-life application, but she also expressed a recognition that this change was for the best. So while Tabitha's FSMAS scores dropped at the end of the year, in reality she developed a disposition towards mathematics that was more productive. Ava came into the year classifying herself as not a "math person" but gave intellectual assent to the notion that mathematics is an important field to study because the value of being a well-rounded educated person had been instilled in her. By the end of the service-learning project she was able to articulate the worth and value of a math education in much more personal and immediate terms; mathematics was no longer something abstractly beneficial, but practically beneficial to her. Ava never fully left behind the notion of not being a "math person" but her disposition towards mathematics certainly became more productive over the course of the year. John came into the year with a high FSMAS scores and a high aptitude for mathematics, even expressing his intention to major in math in college. The engaging nature of the service-learning project pressed John to deepen his understanding of how mathematics can applied and brought him to see that mathematics is not just about applications in science and engineering, but also in service contexts. While John's disposition could have already been summarized as productive coming into the project, that disposition was arguably strengthened through the project. Charlotte began the year with very low FSMAS scores and, like Ava, described herself as not a "math person." Through the project Charlotte became one of the most vocal students in the case study on how positively the service-learning project influenced her change to a more positive view of mathematics:

Charlotte: I think that I do more math, like this year I've done more math, and my outlook has changed on that, just because the service-learning project has been more engaging and more exciting than sitting down and taking notes, and I really wanted to use what I've learned throughout the year and actually apply it, so I think it was more engaging and more fun.

Mason began the year with one of the lowest FSMAS scores that was recorded from the entire class. While harboring a very negative attitude towards mathematics, the prospect of being involved in a service project was extremely appealing to Mason as he expressed placing a great deal of importance on forming relationships with others. While purely the relational side grabbed his interest at the beginning, by the end of the project Mason was articulating how the experience had begun to change his views of mathematics and he reported one of the largest increases in FSMAS scores by the end of the year. When asked to comment on if he feels the FSMAS survey was correctly relaying that his attitude towards mathematics had become more positive:

Mason: Yeah, definitely, much more positive. It was hard, don't get me wrong and I'm not saying I'm no good at math thing didn't change, but I do think ... I should've changed my ... I am sure that I can learn it, because I am sure I can learn it. It just will take longer and when you don't feel so completely discouraged about it ... When you do feel that you do have shot to understand it and learn it, for me at least it really raises my attitude towards it. It doesn't feel like

it's this hopeless thing that I just have to suffer through. It is kind-of just a hill you climb, right?

This statement by Mason embodies the ideal of a productive disposition: while the student doesn't expect to perform math perfectly or always enjoy it, math is no longer seen as hopeless and discouraging, but something the student is capable of doing and succeeding at.

In summary, each student in the case study can be said to have increased in his or her productive disposition towards mathematics and each student tied that increase to their involvement in the service-learning project.

**Research Question 3: To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?**

Having now seen the alignment between the affective outcomes of service-learning and the affective objectives stated in national policy documents on math education, the final question this study addresses is the viability of service-learning as an implementable practice to achieve these affective outcomes.

First, we examine the student response to an end-of-the-year survey on community-based learning (Appendix F). Two statements in particular on this survey pertain to the research question at hand. The first is the statement: "I feel I would have learned more from this course if more time was spent in the classroom instead of doing community work." Student responses to this statement give an indication if service-learning is a valuable learning experience and worth implementing in place of typical classroom work. When considering if service-learning offers a viable means of achieving

the affective objectives of national policy documents on the aims of mathematics education, an important factor to consider is the value the students place on having undertaken the experience. A pedagogical practice isn't viable to implement as part of educational policy if it can't be determined to benefit the students it impacts. Figure 14 below summarizes student responses to this statement.

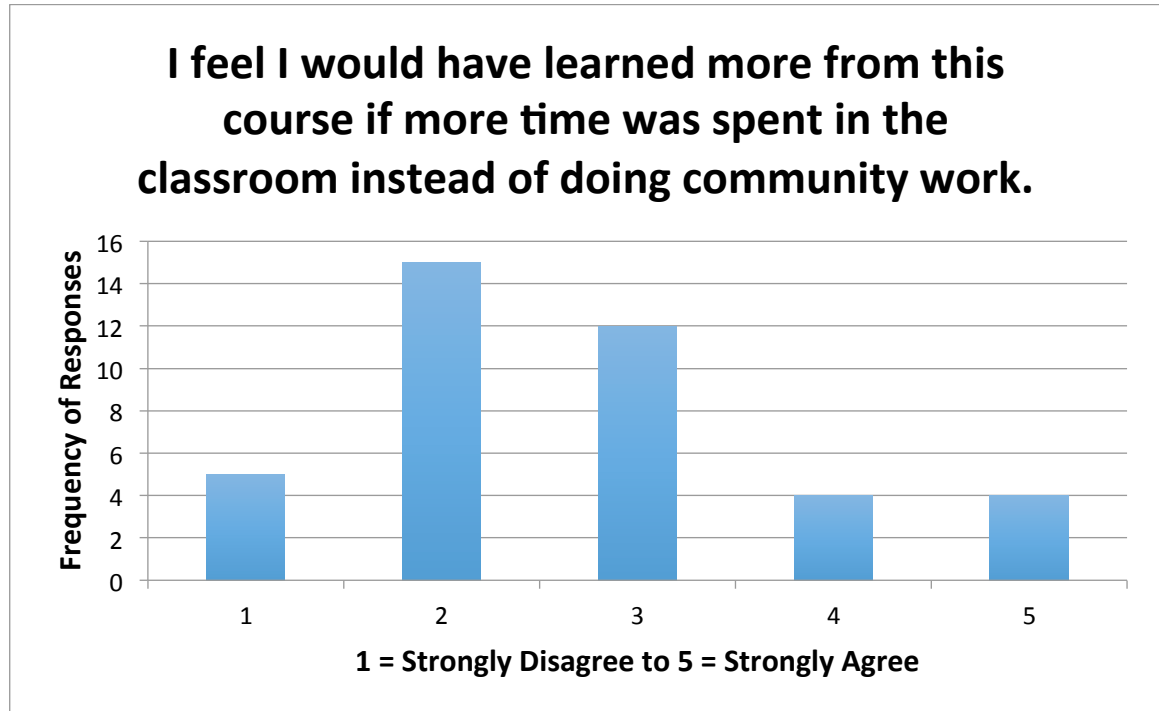


Figure 14: Summary of CBSL Survey Responses Related to Time Allocation

The average student response was 2.675. When tested against a null hypothesis of  $\mu = 3$ , the resulting  $p$ -value was 0.04, which is significant at a 5% significance level. Students clearly responded in a negative way to this statement, indicating that they did NOT feel that the standard practice of classroom learning would have had a greater impact on them than the service-learning experience. In analyzing student responses to interview questions and journal prompts above, it was noted that it is important to consider the distinction in student responses about finding the mathematics of the course

worthwhile to learn versus the service work itself being worthwhile to be involved in. It was argued that in a properly developed service-learning project there should be no such distinction; the mathematics is an integral part of the service so one cannot be viewed as valuable without the other. In that vein it is worth noting the analysis that was done above that clearly indicated how students viewed the service-learning experience (and the mathematics involved) as being worthwhile; the endeavor was valuable and worth the time and effort spent. Students viewed service-learning as worthwhile and a better learning experience than what they were accustomed to in the classroom. This overwhelmingly positive student reception of the service-learning project, along with the alignment between service-learning and developing a productive disposition outlined in research question 2, gives a clear indication that service-learning can serve as a realistically implementable teaching practice that can practically develop students' productive disposition towards mathematics. Mason discussed this notion in his final interview when asked if he viewed the project as a success:

Mason:           Like a said earlier, it's results based. If this ends up helping people and the [the partner organization] really takes off and can point to our survey and say, "You guys helped us." Then, I think it is a success. I don't think this is going to be a failure in any way, unless you are talking ... the opportunity cost of us going out and doing that could have been used in a much better way in the classroom or something. I think there is so much more to life than just learning and sitting in a classroom and learning. I really liked the going out

and doing something with what you've learned. I thought that was great.

The second statement from the survey that is applicable to this research question is the statement: “The idea of combining work in the community with school coursework should be practiced in more classes.” Student responses to this statement give an indication that they found the service-learning experience to be valuable enough that they recommend its increased usage. When considering if service-learning offers a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education, an important factor to consider is not only the value the students place on having undertaken the experience as they look back, but also looking forward, considering if students would recommend the practice be implemented again. Figure 15 below summarizes student responses to this statement.

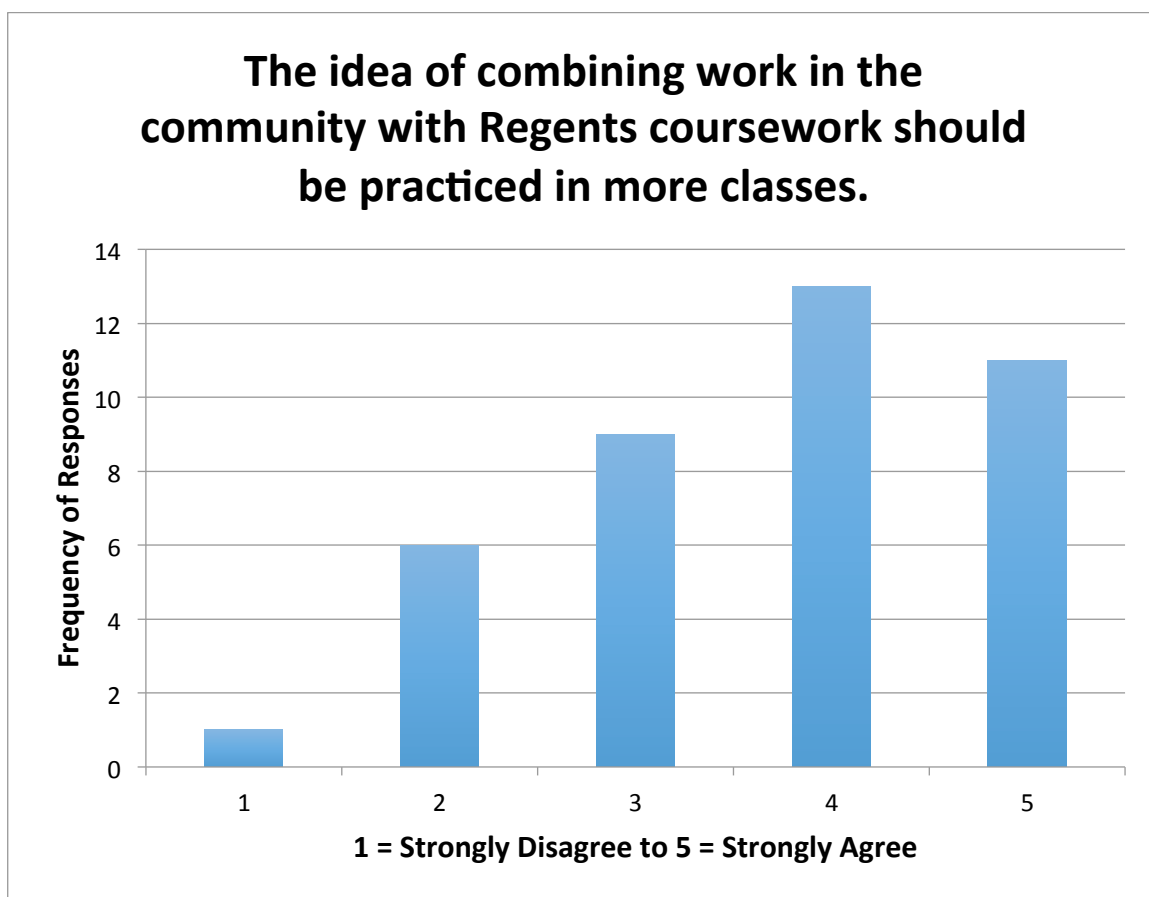


Figure 15: Summary of CBSL Survey Responses Related to SL Implementation

The average student response was 3.675. When tested against a null hypothesis of  $\mu = 3$ , the resulting  $p$ -value was essentially 0, which is significant at any reasonable significance level. Students overwhelmingly commented that they believe service-learning should be implemented in more courses. In the end-of-the-year interview, each student was asked to comment on if they would recommend service-learning in other courses. Below are their responses.

Interviewer: If another teacher was considering doing something similar to this project with their students, based on your experience would you recommend that they do so and why or not?



- Tabitha: I would recommend that they do so because it's a really cool concept.... I think learning to practically apply what your learning in the classroom is important.
- Ava: Yeah. Just ... I feel like I'm being really repetitive, but just having the real world experience of it just makes it more ... I guess you can just see the results of it more.
- John: I would but I'd also say that for this project it worked out very well because we could make a survey and this specific class it worked out well because ... I mean if it was a math class that ... I'd say it's hard to design a type of experiment in a literature class about something like this, but if you could find some way to do it, I feel like it would be very helpful because it's an interactive way to see it.
- Charlotte: Yes, absolutely. Because I think it just helps children better understand what they're learning, because I know in the classroom, anything changing it up outside of the classroom is helpful, and it helps the children make a connection between service and learning, that those two aren't completely separate, but that they can actually be used together.
- Mason: Yeah. It depends on the motive. I just thought it was a lot of fun and I thought it really changed my view of stats. We started doing this and it really picked up at a time when I was really struggling in

it. It really made me think, it's not so bad. I can do this. I can do this.

Every student in the case study commented that they believed service-learning should be used in other courses. Apart from just the personal preferences of the students, and their speculation that service-learning would be beneficial if it were to be used more, it is important to recall statements by Ava, Charlotte, and John who all recalled positively their previous experience in a service-learning project in geometry.

Ava: I definitely think [service-learning projects] are awesome. From geometry, I don't remember every single theorem that we learned at all, but I definitely remember doing that project for [the partner organization]... I think it [service-learning] definitely is more effective for getting a general point across.

John: I remember the gazebo problem in geometry and that was extremely fun and it seemed like we were actually benefiting the [partner organization] community even though we were only high school freshman.

Charlotte: Before, my answers are kind of the same, but thinking math is a waste of time, because before, once again, I just thought that math didn't really apply to anything besides math classes, because I never thought I'd be using sine and cosine in the real world or any of geometry in the real world, but now, through our service project and through the geometry project of creating a little tent thing for the RVs, I realized that math can be used in more ways than I

thought. They can be used in the real world and not just in a classroom

It is also worth considering Tabitha's comment at the end of year when asked to explain why she thinks her FSMAS scores declined at the end of the year.

Tabitha: Yeah, I think because we've never had to practically apply [math] before and because it's like a completely new concept for us. I think I just really, it made me uneasy to know that like, I couldn't, like that that was extremely difficult for me to know that like I can learn concepts in the classroom but when it comes to practically applying it, I was kind of, not able. Like maybe if we had been like doing service projects like from freshman year to now, then I would be like more comfortable with it and I would like be able to think outside the box of what we're taught but, yeah.

Tabitha, who expressed uneasiness at realizing that she had never had to apply her classroom knowledge in real-life situations, expresses that her experience could have been different had she been involved with service-learning projects since her freshmen year. While student preferences for service-learning should not be the only factor considered when determining if service-learning is a viable strategy to implement to achieve the affective learning objectives of national policy documents on math education, it is nonetheless significant to note how each student in the case study speaks very positively of service-learning as way to engage with mathematics. In other words, there is nothing in this study that would discount the notion that service-learning could

legitimately be implemented in meaningful ways at a broad level as a practical way of developing productive dispositions in students.

## **CHAPTER VIII: DISCUSSION**

### **Introduction**

The purpose of this case study was to analyze the role of service-learning in the cultivation of mathematical affections for students in a suburban high school mathematics classroom as they participated in a service-learning project. The cultivation of mathematical affections is generally defined as developing a consistent appreciation for the discipline of mathematics apart from cognitive achievement on formal assessments. Service-learning was examined as a potential pedagogical tool that can be utilized to develop a habitual inclination to see mathematics as worthwhile.

### **Major Findings of the Study**

The study sought to answer the following research questions:

1. To what extent does service-learning impact the cultivation of mathematical affections among students?
2. What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?
3. To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?

*Research Question 1: To what extent does service-learning impact the cultivation of mathematical affections among students?*

In one sense this research question can be answered by looking holistically at the case studies above to affirm that clearly service-learning has an affective impact on

students as they learn mathematics. At an individual level it is worth noting that every student in the case study made an explicit reference to the service-learning project as indicating some change or impact that occurred for them at an affective level. Students seem to regularly reach the *organizing* stage of Krathwohl's affective domain: bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system. A few students, particularly the ones who had prior experience with service-learning in mathematics, could be said to have potentially reached the *characterizing* stage (though a full analysis of the characterizing stage would need to take place over more than just the course of one school year). The students also regularly attribute the method by which they reached the *organizing* stage to a change in the routine, or to use Smith's (2009) term, a change in the "liturgies" of the mathematics class. This study then seems to give clear evidence of how service-learning engages students at a deeply affective level and provides a venue for students to wrestle with their valuation of mathematics.

*Research Question 2: What is the alignment between the affective objectives of national policy documents on the aims of mathematics education and the affective outcomes on students participating in a service-learning project?*

The student interviews, field observations, and collected reflection journals were coded following the three major themes of a productive dispositions: seeing math as sensible, useful, and worthwhile. The working definition of being sensible is "to be reasonable or comprehensible, rational." The main idea for this term is that it implies mathematics is understandable, that the service-learning project has in some way aided the student in making intellectual sense of the mathematics involved. In the case study

group, each student came into the class and the project with very different views on how much sense mathematics made to them. While students might make assent to math being logical and rational, when that abstract statement was made more personal to their own experience they tended to express frustrations or confusions with the mathematics they see in school. However, through the project each student was able to articulate the sensibleness of the course material. The project served to solidify each students' understanding of the course and their ability to make sense of the mathematics involved.

The working definition of being useful is "being of practical use, serving some purpose." The main idea for this term is that it implies mathematics has a purpose, that the service-learning project has in some way aided the student in seeing the practical applications of mathematics. While all students in the case study expressed their understandings differently, all of them indicated that the service-learning project improved their perspective on the usefulness of mathematics. A typical response at the beginning of the year was to offer an assent to math being useful, but for somebody else in some different job, in some distant future. After the project, every student was able to articulate how the math they were learning was useful in their immediate context. The usefulness of mathematics became a more personal experience.

The working definition of being worthwhile is "being rewarding, valuable to justify time or effort spent." The main idea for this term is that it implies mathematics is worth putting time and energy into learning; mathematics offers something valuable and rewarding for everyone. In the context of this study this means that the students indicate that the mathematics involved in the service-learning project was an important task to undertake, has beneficial outcomes, and was worth the effort that was committed. In

determining if the students in the case study found mathematics to be worthwhile, one of the hardest distinctions to make was if they were expressing the worthwhileness of the experience in terms of the mathematics involved or purely in terms of the service. In other words, could students find value and worth in the service but still not see the mathematics as worthwhile? As addressed previously, ideally the answer to this question should be ‘no’ for any well-designed service-learning project. A well-designed service-learning project necessarily involves integrating the content of the course into the service being performed. So then, if a student says that they found the service valuable, that service involved performing mathematics. In this study, while some students were initially drawn to the service-learning project because they found the concept of service in general as worthwhile, by the end of the project each student was able to articulate that the mathematics involved in the project was worth the effort spent to learn and apply it.

Each student in the case study was able to articulate, in their own unique way, their understanding of mathematics as sensible, useful, and worthwhile. In summary, each student in the case study can be said to have increased in his or her productive disposition towards mathematics and each student tied that increase to their involvement in the service-learning project.

*Research Question 3: To what extent does service-learning offer a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education?*

Having now seen the alignment between the affective outcomes of service-learning and the affective objectives stated in national policy documents on math



education, the final question this study addresses is the viability of service-learning as an implementable practice to achieve these affective outcomes.

Students gave an indication that service-learning is a valuable learning experience and worth implementing in place of typical classroom work. When considering if service-learning offers a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education, an important factor to consider is the value the students place on having undertaken the experience. A pedagogical practice isn't viable to implement as part of educational policy if it can't be determined to benefit the students it impacts. Students viewed service-learning as worthwhile and a better learning experience than what they were accustomed to in the classroom. This overwhelmingly positive student reception of the service-learning project, along with the alignment between service-learning and developing a productive disposition outlined in research question 2, gives a clear indication that service-learning can serve as a realistically implementable teaching practice that can practically develop students' productive disposition towards mathematics.

Students also gave an indication that they found the service-learning experience to be valuable enough that they recommend its increased usage. When considering if service-learning offers a viable means of achieving the affective objectives of national policy documents on the aims of mathematics education, an important factor to consider is not only the value the students place on having undertaken the experience as they look back, but also looking forward, considering if students would recommend the practice be implemented again. Students overwhelmingly commented that they believe service-learning should be implemented in more courses.

While student preferences for service-learning should not be the only factor considered when determining if service-learning is a viable strategy to implement to achieve the affective learning objectives of national policy documents on math education, it is nonetheless significant to note how each student in the case study speaks very positively of service-learning as way to engage with mathematics. In other words, there is nothing in this study that would discount the notion that service-learning could legitimately be implemented in meaningful ways at a broad level as a practical way of developing productive dispositions in students.

#### *Relation to Similar Studies*

In the past decade, there are two unpublished dissertations that are noteworthy in their similarity to this study, both of which focus on the impact of service-learning in the context of mathematics. Roemer (2009) sought to determine if the teaching and learning of mathematics would be enhanced by service-learning, in the context of a community college course. Where this present study differs from Roemer is the focus on the affective impact of service-learning. Roemer notes that practicable connections do exist between service-learning and mathematics, however results regarding enhanced teaching and learning (cognitive gains) through service-learning are mixed. Roemer argues that the reason for mixed results is that motivation in mathematics and community service is impacted by general student motivation and the quality of the service experience. In other words, Roemer's work seems to suggest that there is more to be gleaned by examining service-learning through an affective lens. Roemer also notes in her conclusion that reflection is critical to learning. This study takes up with examining service-learning for its affective impact on students, with a focus on the reflective practices of service-

learning as a means of cultivating a productive disposition in students. This study found that service-learning does have a positive impact on the development of productive disposition in students regardless of cognitive gains. Students at both the low and high end of the spectrum in terms of cognitive achievement in the course all experienced positive growth in their productive disposition towards mathematics.

The second dissertation of note is the work of Leong (2006). Leong 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. These participants reported greater confidence doing statistics and attributed this confidence, in part, to service-learning. What is most notable about Leong's work is that it is one of the few pieces of research on service-learning in high school mathematics and also the fact that Leong notes these results provide evidence that service-learning can be utilized to solidify positive attitudes and beliefs regarding statistics among high school students. Leong offers service-learning as a clear vehicle to impacting student affect in mathematics. This study has verified Leong's results.

Where this study differs from Leong is that Leong analyzed service-learning through McLeod's (1992) framework of the affective domain, whereas this study re-conceptualized affect based on the work of Smith (2009) and focused specifically on the development of productive disposition. As discussed in the literature review, McLeod's basic argument is to re-conceptualize affective learning into three main areas: beliefs, attitudes, and emotions. I would argue that a potential problem with McLeod's approach is that only the category of attitude fits properly within the affective domain of learning as developed by Krathwohl (1964). Leong discusses the positive attitudes developed by

students towards mathematics through engagement in service-learning and this study has confirmed this result. However, using the framework of Smith (2009), this study has taken the perspective that beliefs (which Leong focuses on as well) are better understood as cognitive rather than affective. Instead of beliefs about mathematics this study has focused specifically on the description of a productive disposition offered by the National Research Council (2001) with an emphasis on examining the practicality of service-learning as a means of achieving stated policy objectives on the aims of math education (rather than Leong's emphasis on generically improving student attitude). This emphasis on practical application now leads to a discussion of the clinical relevance of the findings of this study.

#### *Clinical Relevance of Findings*

This study has answered the question of *how* mathematics educators might go about the task of cultivating a productive disposition in students. Affective language permeates national published standards on the teaching of mathematics as an ideal we should strive to inculcate into students and now service-learning has demonstrated to be a viable means by which educators can achieve these aims. With service-learning as a pedagogical tool at their disposal, mathematics teachers would no longer need to offer contrived answers to the student questions on when they are ever going to use the material or why they should value the material. Instead, educators can immerse students in meaningful, real-life learning experiences that emphasize affective outcomes in addition to growing students cognitively, providing students a real and tangible understanding of the value and importance of mathematics.

### *Suggestions for Further Research*

In order for teachers to implement service-learning in their mathematics courses they need to be equipped with the resources to do so. This study has demonstrated that service-learning is a viable means of practically achieving the stated affective aims of national policy documents in mathematics education, specifically in terms of developing a productive disposition. The implication of this study then is to recommend service-learning be emphasized amongst governing bodies of mathematics education policy such as NCTM. The College Board which oversees Advanced Placement (AP) curriculum has recently partnered with the service organization We.org to develop curriculum and teacher training for service-learning in AP courses

(<https://advancesinap.collegeboard.org/initiatives/ap-we-service>, accessed January 19, 2017). Similar resources need to be provided for mathematics teachers at a broader level if educators are truly committed to developing a productive disposition in students. As noted in the literature review on service-learning it is key that teachers undergo the appropriate training to understand distinctions in types of service-learning projects (discipline-based v. problem-based), how to structure reflections, and how to offer assessments. Following the argument of this study the key is to offer students tangible changes to traditional classroom liturgies in mathematics through service-learning with an emphasis on reflection.

At the very least, it is recommended that further research be done with different student groups in different contexts to measure the impact of service-learning on a wider sample of students' mathematical affections. A longitudinal study is also recommended to trace the impact of service-learning across multiple years to determine if a greater

percentage of students begin to alter their characterizations of themselves in terms of their mathematical ability

### **Limitations of the Study**

One of the major limitations of this study is that I as the researcher was also the instructor of the course in which the students were performing the service-learning project. I functioned as a participant observer, immersed in the daily school lives of the students in this study (Creswell, 1998). Participant observation is a method of qualitative data collection typically ascribed to an ethnography (Creswell, 1998), in which the focus is on examining a group's patterns of behavior. This study was not interested in discovering the meanings of behavior or culture-sharing interactions amongst students, but rather in examining the students' experience in a bounded service-learning activity. This makes a case study approach more appropriate. In general, the participant observer is concerned with employing multiple overlapping data collection strategies: being fully engaged in experiencing the setting while at the same time observing and talking with other participants about whatever is happening (Patton, 2002). While I participated with the students throughout the service-learning project, I did not participate in exactly the same fashion as I did not take on the role of student myself. As the instructor I had some level of separation from the participating students during the research process.

One potential area for concern is that the students may have felt beholden unto me to provide positive responses either to the FSMAS survey or to qualitative measures during the study such as the student responses in reflective journals or in interviews. It was made clear to students from the very beginning (and students were reminded throughout the project) that their responses to the FSMAS survey, journal prompts, or

interview questions had no bearing on their final grade on the project or in the course.

One key component of the service-learning project was to organize it in such a way as to have the partner organization have a significant say in the evaluation of the final project. In this way I hoped to be seen as a facilitator in the partnership between the partner organization and the students and not the ultimate authority on the project. This hopefully provided students an opening to share both positive and negative responses with me, viewing me as someone who is on their side to help develop the best product possible for their client, the partnering organization. In addition to the structuring of the service-learning project so as students don't feel beholden unto me as their instructor, I also have the benefit of an established history with this course at this school. This was my fourth year teaching AP Statistics at this school and a service-learning project, including aspects of reflection and student experience surveys, has been utilized every year. The part and parcel of the course was not changed in order to gather data for this study. Though more reflections were asked of students this year than in previous years, reflection is not a new component added to the course. In other words, the amount of work and type of responses required of the students was not affected by their involvement in the study, thus opening the door for them to respond freely as students have for the past several years. And as can be noted in the student responses included in this study, they openly gave negative responses in regards to their perception of mathematics and they openly shared difficulties they had with the service-learning project. In all, I believe that the data gathered is reliable in that it represents the true experience of each student in the case study.

Another concern in this study is the effect I have as an inquirer and the extent to which the predispositions or biases of the evaluator may affect data analysis and interpretations (Patton, 2002). As the researcher, I was sure to clearly state my own previous experience and disposition toward service-learning in the final data analysis. Rigorous data collection and analytical procedures like triangulation are aimed at substantiating the validity of the data and minimizing the inquirer biases (Patton, 2002).

Finally, one additional limitation is that this study was performed on AP Statistics students. While AP Statistics is offered as a math course there are some clear distinctions between the disciplines of mathematics and statistics. So, one may wonder if this study is about cultivating statistical affections rather than mathematical ones. While there admittedly is a distinction between statistics and mathematics at higher levels of education (post-secondary and beyond), what is important in this study is the perception of the students involved. AP Statistics is offered as a math credit, taught in a math classroom in the mathematics wing of the school building, and has a math pre-requisite of Algebra II. While students' views on statistics as separable from the discipline of mathematics may evolve over time, it is safe to assume that as juniors and seniors in high school that distinction has not yet been made – making the results of studying service-learning in a statistics course applicable to other secondary mathematics courses.

## **Conclusion**

The data gathered from this study clearly indicates that the practice of service-learning in a mathematics course led to engaging students at a deep affective level, with every student demonstrating wrestling through Krathwohl's advanced stage of organizing; bringing together different values, resolving conflicts between them, and



beginning the building of an internally consistent value system. Not only were students engaged at a deeply affective level, they were engaged in a positive way that led to a more productive disposition; of seeing mathematics as sensible, useful, and worthwhile (National Research Council, 2001, p. 116). Students were clearly demonstrating the building of an internal value system in a positive way about mathematics, thereby cultivating mathematical affections. To be clear, service-learning is not being advocated as a “fix-all” pedagogical approach. Students (particularly Tabitha, Ava, and Mason) still harbored negative feelings towards mathematics; feelings that were deep-seated and had been formed over the course of years during their schooling. While some students (particularly those who had previously been involved in service-learning in mathematics) indicated that they may be on the threshold of Krathwohl’s most advanced domain of characterizing (individual has a value system that has controlled his or her behavior for a sufficiently long time for him or her to develop a characteristic “life-style” – thus the behavior is pervasive, consistent, and predictable), the reality is that this could not be measured over the course of a single school year. Much work would need to be done to unseat negative characterizations students have about mathematics. While service-learning doesn’t complete this task fully, this study has demonstrated that it does make substantial progress. Students deepened their understanding of the ways in which mathematics can be applied, seeing it as useful in their immediate context rather than as some potential skill in the future, and seeing it as useful for the service of others rather than for the student’s own advancement. The regular liturgies of the classroom that were instituted in order to emphasize these points, such as interacting with the partner service

organization, outside speakers, readings, and reflections, were mentioned by every student as having contributed to their growth in a productive disposition.

The goal of this study is best summarized by Mason at the end of the year when asked to look back and reflect on his experiences over the course of the year with the service-learning project in mathematics:

Mason: It was hard, don't get me wrong and I'm not saying I'm no good at math thing didn't change, but I do think ... I should've changed my ... I am sure that I can learn it, because I am sure I can learn it. It just will take longer and when you don't feel so completely discouraged about it ... When you do feel that you do have shot to understand it and learn it, for me at least it really raises my attitude towards it. It doesn't feel like it's this hopeless thing that I just have to suffer through. It is kind-of just a hill you climb, right?

Students may still feel they are no good at math – that is a very deep-seated belief that is hard to dislodge (or at least needs to be dislodged at an earlier age than high school). But through the service-learning project Mason's attitude improved as he became engaged and sure that he could learn. His having success in mathematics is no longer hopeless. It will take work, but it is no longer hopeless. This is the essence of cultivating mathematical affections.

## **APPENDIX SECTION**

APPENDIX A: Modified Fennema-Sherman Math Attitude Scale

APPENDIX B: Interview Protocol – Beginning of the Project

APPENDIX C: Reflection Journal Prompts

APPENDIX D: Observation Protocol and Sample Documentation

APPENDIX E: Interview Protocol – End of the Project

APPENDIX F: End of Year Project Survey

APPENDIX G: Student Handout: Project Overview

## APPENDIX A

### Modified Fennema-Sherman Math Attitudes Scale<sup>5</sup>

#### The confidence in learning mathematics scale (C)

C3+ I am sure that I can learn mathematics

C7- I'm no good at math

#### The mathematics anxiety scale (A)

A1+ Math doesn't scare me at all

A2+ It wouldn't bother me at all to take more math courses

A8- Mathematics makes me feel uncomfortable, restless, irritable, and impatient

A12- Mathematics makes me feel uneasy and confused

#### The effectance motivation scale in mathematics (E)

E2+ Mathematics is enjoyable and stimulating to me

E3+ When a math problem arises that I can't immediately solve, I stick with it until I have the solution

E11- I would rather have someone give me the solution to a difficult math problem than have to work it out for myself

E12- I do as little work in math as possible

#### The mathematics usefulness scale (U)

U2+ I study mathematics because I know how useful it is

U4+ Mathematics is a worthwhile and necessary subject

U6+ I will use mathematics in many ways as an adult

U7- Mathematics is of no relevance to my life

U10- Taking mathematics is a waste of time

U12- I expect to have little use for mathematics when I get out of school

---

<sup>5</sup> The labeling and phrasing of each statement comes from Mulhern & Rae (1998) based on Fennema & Sherman (1976). The '+' symbol indicates a positive wording of a statement while the '-' symbol indicates a negative wording of a statement. The negative statements will be scored on a reversed Likert scale so that an overall high average score will indicate positive responses and an overall low average score will indicate negative responses.

## APPENDIX B

### Interview Protocol – Beginning of the Project

Thank you for taking the time to be interviewed for this project. I am going to ask you a few questions in regards to your experience with the AP Statistics project this year.

To be clear, your participation in this interview and the answers that you provide will neither have impact on your grade in the class nor your personal standing in the eyes of your instructor. These questions have no “right,” “wrong,” or even “expected” answer. The purpose of the interviews is to gain an objective picture of service-learning projects by recording the personal experience of students.

This interview will be recorded. Your responses on this interview and any follow-up interviews will be kept confidential.

1. First, let’s talk about the “math attitude survey” that you completed in the fall. You were sent a copy of your responses as well as a copy of your first journal entry that you wrote in response to the survey. I have also provided hard copies for your reference. I want to focus on just a few of your responses and give you the opportunity to add some narrative to your quantitative responses.

*(Follow with questions examining the extreme valued responses of students and/or the responses they wrote about in their journal entry).*

2. Describe your initial impressions of the project when it was introduced last fall?
3. Describe your experience from the beginning of the project until now.
  - a. Describe the project in your own words. Describe the work you are doing in the community for this course. Describe your relationship with the community partner and the project.
  - b. Describe your interaction with your community partner. What role have they played in your learning?
  - c. Has the project unfolded the way that you expected it to? What aspects of this project have been exciting, challenging, frustrating, rewarding for you?
  - d. Did/do you have any fears or concerns about working in the community as part of this class? What are those concerns?

4. This project is an example of a service-learning project. Service-learning projects allow students an opportunity to apply what they are learning in the classroom in the context of community service. What is your impression of service-learning in general as a way to engage in a class in comparison with more traditional classroom methods?
  - a. What have you learned about the community through this experience? What have you learn in the community that connected the content of this course? How was that connection made?
  - b. Can you describe the connections between community service work and the content of this class? Are there any connections between the community service and the classroom discussions, required readings, assignments? Has there been a good balance of course time and community (project) time?
  - c. If another teacher was considering doing something similar to this project with their students, based on your experience, would you recommend that they do so? Why or why not?
5. Describe your expectations on the project moving forward.
  - a. What are your own personal learning goals for this experience? What are the goals of the class?
  - b. What aspects of this project do you expect to be exciting, challenging, frustrating, rewarding for you?

## APPENDIX C

### Reflection Journal Prompts<sup>6</sup>

#### Fall Semester

1. You were recently asked to complete a “math attitude” survey in which you responded to how accurately 16 statements described you. For your first reflection journal entry, select **at least 3** of the statements and explain in your own words *why* you responded to them the way you did on the survey.
2. For the AP Stat project this year we will be working with a partner organization. The founder, CEO, and president will be visiting our class to talk about the organization and what we will be doing in AP Stat to partner with them. I would like for you to come to that class with some background knowledge on the organization and having already spent some time thinking through how statistics might be meaningfully applied to help their cause. This journal entry will have two parts:
  - a. Part 1: Read the article I gave you that discusses the work of the partner organization. Also, spend some time exploring their website. In your journal, share your thoughts/initial impressions about the organization and their mission. If applicable, discuss any previous interaction or volunteer work with the organization.
  - b. Part 2: Respond to the following question: What are your expectations for this project? In other words: having not been provided with any details yet on the nature of the project, but having an understanding of the organization and (hopefully) some understanding of statistics, how do you expect a statistical project with this organization to look? What are your initial thoughts how applicable or how important statistics is for the work of the organization?
3. For this journal entry I want you to take some time to process all the information that has been presented to you over the last two days in regards to the project. I would like you to do so in three specific ways:
  - a. Respond to the presentation from the organization. The following questions may be useful in guiding your thoughts: What was the biggest take away from the presentation? What was communicated as the purpose of the organization’s ministry? What stood out to you about what the organization is doing? What was your impression of what the organization wanted to do with statistics?

---

<sup>6</sup> Some coming from Webster Vinsonhaler (2005), modified for a high school context as opposed to a college setting. Though this list splits the reflection questions into pre-service and mid-service/end-of-service, modified versions of these questions can be used as prompts during the regular journaling process throughout the project.

- b. Respond to the chapter reading from the book *Chasing the Scream* that details the “Rat Park” experiment. The following questions may be useful in guiding your thoughts: How does this chapter apply to the project?
  - c. Respond to the class conversation. As a class we settled on the following main question to address in this project: *Is the organization’s approach to treating homelessness successfully improving the quality of life of the people it serves, as compared to their life on the streets?* The following questions may be useful in guiding your thoughts: In what ways do you think this is a good/bad summative question for the project? How does this question integrate the organization’s presentation with the insight you gained from *Chasing the Scream*? If you think the question should be changed, what should it be changed to, and why?
- 4. For this journal entry you need to read the article I provided you on homelessness in our city. Earlier in the year you were given assignments to read an article and then write a one page summary. For those assignments I asked for a paragraph summary and then a paragraph of interpreting/applying the results to what we are learning. In this assignment I want the **whole paper** to be interpretation/application. You **don’t need** to summarize the article first. Write one page in response to the article in your reflection journal as your 4th journal entry. In your response you should reflect on how statistics was used in the article, how the topics address apply to our project, and how what we are doing may have an impact.
- 5. For the last journal entry of the fall, I simply want to hear your thoughts on the project thus far. Please briefly summarize your evaluation of the project to this point. Some questions that you might consider:
  - a. In journal entry #2 you addressed your expectations and understandings of the project and our partnership with the organization. How have those expectations unfolded or changed as the semester progressed?
  - b. What aspects of this project do have you found to be exciting, challenging, frustrating, rewarding for you?
  - c. How have you understood the relationship between class work on statistics and the project?
  - d. What, if anything, would you change about the design of the service-learning project?
  - e. What specific comments and recommendations do you have regarding communicating with the community partner, working in groups, logistics, and the time commitment required for the project?
  - f. What kind of help will you need from your instructor or Mobile Loaves and Fishes to make your project successful?



## Spring Semester

1. In this first spring journal entry I would like to you to take some time to process all the information that has been set before you this week. At the beginning of this week you received the project documents. This first journal entry is meant to address two things:
  - a. There is a lot to digest in the above documents and this journal entry is meant to provide you some space in which to do so. The following questions may be useful in guiding your writing. You can respond to all of these questions or none of them. The point is that you simply take time to consider the task before you and begin to process the expectations, fears, anxieties, excitements, etc. that accompany it.
    - i. What are the goals we should have as a class on this project? What are the goals you have as an individual on this project?
    - ii. What do you perceive as potential hurdles to reaching these goals, whether from within this class or from without?
    - iii. What knowledge will you need to apply from this class in order to complete the project successfully?
    - iv. What personal qualities (leadership, communication skills, compassion, etc) will you need to complete the project successfully?
    - v. What aspects of this project do you expect to be exciting, challenging, frustrating, rewarding for you?
    - vi. What kind of help will you need from your instructor, from the school, or from the organization to make your project successful?
    - vii. Describe what you expect your contribution to be to the final product of this project.
  - b. There are several what we'll term "Touchstone Questions" that we'll return to throughout the project. Prior to jumping into the spring portion of our project, how would you respond to the following:
    - i. Why should you value (or devalue) your math education?
    - ii. At our school the word 'service' is used often. Define what this means in your own words.
2. After reading your first journal entries of the spring, a common theme emerged: having some level of anxiety or uncertainty about how to relate authentically with the formerly homeless people that we are surveying. As a class we will be taking some practical steps to address this concern prior to administering the survey. This second journal entry for the spring is meant to begin the process of understanding (as best we can) the life situation of those we are surveying.

- a. First, get to know the story behind one of the residents of the property by reading his story and watching a video interview with him.
  - b. Now, for this journal entry, I am going to ask you to do some perspective writing. Imagine you are this resident (or any other resident of the property) to the best of your ability. I would like you to write about two things: what a typical day might look like and what a day being interviewed/surveyed might look like. Below are some guiding questions for you to consider.
    - i. **A typical day:** Imagine you are this resident (or any other resident of the property) and you wake up in the morning. Where are you? In what kind of room and in what kind of bed? What do you eat for breakfast? What do you do with your day? What do you enjoy? What do you dislike? What are you looking forward to? What are you hoping will happen? What do you dread?
    - ii. **A day being interviewed/surveyed:** Still imagining you are this resident (or any other resident of the property), and a group of high school students arrives on the property to conduct a survey. What do you think about these people who are visiting and interviewing you? How do these people act toward you? Is their presence welcomed or helpful? What do you wish they would do differently?
  - c. While this is an exercise in imagination and has no right/wrong answers, I hope it starts you thinking on some of the practical ways we can take steps to be authentic in the way we relate to and interview the residents of the property.
3. This week a guest speaker will be visiting with our class to share about the experiences that led her to write a book on homelessness in our city. Your journal entry for this week will be to reflect on the guest speaker's presentation.
    - a. In preparation for her visit, I have given you posted an excerpt from her book.
    - b. You're overall guiding question for this journal entry: How did what the guest speaker had to say (or how did your reading from her book) impact your own view of the homeless? How did it impact your view of this project or the preparation that you put in to administering the survey?
  4. For this journal entry I would like you to do 3 things:
    - a. I have shared with you the VI-SPDAT Survey Manual. VI-SPDAT stands for the Vulnerability Index - Service Prioritization Decision Assistance Tool. It is a survey that allows organizations that serve the homeless to assess the needs of their clients.

- i. Read pages 4-8 of the VI-SPDAT Survey Manual that explains what the instrument is and how it is to be used by those giving the survey. Also read the document “Survey Advice.”
    - ii. From that reading, what are some things that stand out to you as being important to have under consideration when we are giving our survey? Are there any changes or additions to our survey that you would recommend in light of the introduction to the VI-SPDAT tool?
    - iii. I encourage you to skim through the rest of the VI-SPDAT, noting the questions that are asked. The document offers some helpful advice for each question in terms of acceptable (unbiased) and unacceptable (biased) ways of rephrasing or rewording questions.
  - b. I have also shared with you a PowerPoint of data on the homeless in our city collected by another organization through the VI-SPDAT tool. Read through the presentation. Please comment on what statistics stood out to you and which data displays you found most effective. This will be a good reference as we move forward and consider how to present our results.
  - c. If we assume the Need Analysis Presentation is communicating the results in terms of the *population* of homeless in our city, how can we make use of this report when we run our data analysis on our *sample*? In other words, think about the inference procedures you have learned where we compare a sample to a hypothesized population value. Is there data in this report that touches on the same issues/questions of our survey to allow for a point of comparison between the residents of the property and the entire homeless population of our city? If so, what questions do you notice that are included in both this report and our survey?
5. For this week’s journal entry I would like you to practice giving our survey and then reflect on that experience. You will need to find a parent, teacher, or a friend (not in AP Stats) to volunteer to help you with this assignment. No person can be surveyed twice! So two people in stats cannot pick the same friend, teacher, or parent to survey. Whoever you pick will need to be willing to role-play slightly since they won’t be a formerly chronically homeless person now living on the property. Their answers to the questions are not important. What is important is that you get the experience of going through the entire survey and reflecting on it prior to us driving out to the property to administer it. Please keep in mind what you learned from last week’s journal entry, particularly the survey advice, when you give the survey. Your journal entry should contain the following:
- a. The name of the person you surveyed

- b. A brief description of the setting the survey was given in. (What time of day was it? Where was the survey given? Was it just the two of you or were you in public? etc.)
  - c. How long it took to complete the survey.
  - d. Feedback from the volunteer you surveyed. Sample feedback items might include:
    - i. Were any questions confusing in their wording or answer choices?
    - ii. Did the speaker stay on script?
    - iii. Did the speaker do their best to avoid biasing the responses either in the way they read certain questions or their actions while the survey was in process?
    - iv. Did they feel like the speaker was truly listening to their responses or that the speaker was just recording data?
    - v. Did the volunteer feel respected and that their answers mattered?
  - e. Your reflection on the process. Sample questions you might address: Talk about your comfort level. Given that this was a trial run with a friendly volunteer, think about how you felt during the process and how that might translate to giving the survey for real. What are some things you need to be aware of to help the survey go well? (ex: nerves leading to talking fast, uneasiness over personal questions leading to a change in tone for the way the question is asked, etc.)
  - f. Was it difficult to listen to responses and record them at the same time?
  - g. After this experience, what will you do differently when you give the survey at the property? What will you be the most mindful of when giving the real survey?
6. For this journal entry I would like for you to reflect on the experience of giving the survey. Below are some questions to help guide your reflection. You don't have to answer these questions directly, but read through them to help process and organize your thoughts.
- a. What were your expectations going into giving the survey (either excitement or fears)? Were those expectations met or not?
  - b. What stood out to you the most about your experience? Why?
  - c. What was challenging about giving the survey? What was rewarding?
  - d. Were you prepared to perform this task? If not, what would have prepared you more?
  - e. What did you learn about the property through this process? What did you learn about homelessness? What did you learn about yourself?
7. For this journal entry I want to return to the "Touchstone Questions" that appeared in your first journal entry of the spring. Now that we are at the midway point of the spring portion of our project (in other words, now that we have given

the survey), I would like you to respond to the following questions. Your answers may or may not be the same as your first spring journal entry. The point of this exercise is for you to stop and think: if my answers are the same, why haven't they changed? If my answers are different, why are they different?

- a. Why should you value (or devalue) your math education?
  - b. At our school the word 'service' is used often. Define what this means in your own words.
8. For this journal entry I would like you to reflect on the data analysis that we have been doing in class based on our survey results. To help organize your thoughts, respond to the following questions:
  - a. What methods are you using to analyze the data and why? Have you found it hard or easy and why?
  - b. Did you feel prepared for the data analysis? Did it make sense when to use different inference methods that we have learned over the year?
  - c. After doing data analysis, can you explain the connection between the community service work and the content of this class?
  - d. Did analyzing the results of our service project help solidify concepts from the course?
  - e. Describe some results that stand out to you from your data analysis. How will these results impact the work of the partner organization?
  - f. What did you enjoy about the data analysis? What did you not enjoy?
9. Now that we have completed the project and presented the results to Mobile Loaves and Fishes, I would like you to reflect on the entire process of the project.
  - a. First, please complete a short survey of the course project.
  - b. Using the questions from the survey in step 1 as a guide to organize your thoughts, please share your reflections on your overall impression of the project. Here are some additional questions to consider, though you do not have to answer them directly: How did it go? What did you get out of it? Was it useful? Are there particular aspects that stood out to you? Would you recommend it for future classes? etc.
10. For your very first journal entry of the fall semester you were asked to complete this same "math attitude" survey in which you responded to how accurately 16 statements described you, select **at least 3** of the statements, and explain in your own words why you responded to them the way you did on the survey. For this journal entry I would like you to do this again. You can choose the same 3 statements as you did in the fall or you can choose new ones. Finally, I would like you to give one final answer to the "touchstone questions" of this year. Your answers may or may not be the same as the previous times you have answered these questions. The point of this exercise is for you to stop and think: if my

answers are the same, why haven't they changed? If my answers are different, why are they different?

- a. Why should you value (or devalue) your math education?
- b. At our school the word 'service' is used often. Define what this means in your own words.

## APPENDIX D

### Observation Protocol and Sample Documentation

Engaged Affect				Non-Engaged Affect			
Facial Cues	Physical Gestures	Verbal to Students	Verbal to Teacher	Facial Cues	Physical Gestures	Verbal to Students	Verbal to Teacher

Last day prior to 2 week break

VP already found in proposal

Spring Observation 4  
Proposal Workday

C Block 9:35-9:55

Friday 3/4/16

Engaged Affect				Non-Engaged Affect			
Facial Cues	Physical Gestures	Verbal to Students	Verbal to Teacher	Facial Cues	Physical Gestures	Verbal to Students	Verbal to Teacher
TR focused look at computer X2	TR computer out reference project documents	TR asking questions of others to clarify steps	CW asking questions about unit terminology		AB writing on paper (different assignment)	MB talking in group off topic	
CW focused look at computer X2	CW computer out asking questions X6	CW asking students about unit terminology	TR asking several questions about format			MB laughing in group of boys at computer screen	
TR focused on reading project docs	CW sitting by self on couch to front X4	TR asking student how long this proposal was	CW asking questions			CW talking with students about Euro trip	
CW focused on reading project docs	MB computer out XPS	TR asking student questions	CW asking about unit terminology			X6	
CW focused on reading project docs X2	X4		TR asking questions on spelling terminology			TR asking students about unit assignment	
	TR looking in wallet of student's phone/drink		TR asking question about variability reduction method			TR responding to question of going by tomorrow	
	CW head in hair, stretching back, looking at computer screen					CW stopping on way back to seat to talk to another student	

very clear  
- TR/CW on task involved  
- VP done  
- AB done most likely  
- MB off task

AB talking to other students X6 off topic X4



## APPENDIX E

### Interview Protocol – End of Year

Thank you for taking the time to be interviewed for this project. I am going to ask you a few questions in regards to your experience with the AP Statistics project this year.

To be clear, your participation in this interview and the answers that you provide will neither have impact on your grade in the class nor your personal standing in the eyes of your instructor. These questions have no “right,” “wrong,” or even “expected” answer. The purpose of the interviews is to gain an objective picture of service-learning projects by recording the personal experience of students.

This interview will be recorded. Your responses on this interview and any follow-up interviews will be kept confidential.

1. Describe your experience from the beginning of the project until now.
  - a. Describe the project in your own words. Describe the work you did in the community for this course. Describe your relationship with the community partner and the project.
  - b. Describe your interaction with your community partner. What role did they play in your learning?
  - c. Did the project unfold the way that you expected it to?
  - d. What were your own personal learning goals for this experience? What were the goals of the class? Were they met?
  - e. What aspects of this project were challenging or frustrating for you?
  - f. What aspects of this project were exciting or rewarding for you?
  - g. How would you assess your experience? Was it a success? Why? What factors contributed to the success? What obstacles did you encounter and how did you overcome them?

2. This project is an example of a service-learning project. Service-learning projects allow students an opportunity to apply what they are learning in the classroom in the context of community service. What is your impression of service-learning in general as a way to engage in a class in comparison with more traditional classroom methods?
  - a. What did you learn about the community through this experience?
  - b. Can you describe the connections between community service work and the content of this class? How was that connection made?
  - c. Can you describe the connections between the community service and the classroom discussions, required readings, assignments? Was there a good balance of course time and community (project) time?
  - d. If another teacher was considering doing something similar to this project with their students, based on your experience, would you recommend that they do so? Why or why not?
3. Now, let's talk about the end of year "math attitude survey" that you recently completed. For your reference I have provided hard copies of your responses, as well as the journal entry you wrote in response to the survey. I want to focus on just a few of your responses and give you the opportunity to add some narrative to your quantitative responses.

*(Follow with questions examining the extreme valued responses of students and/or the responses they wrote about in their journal entry).*
4. In comparing your responses to the math attitude survey from the beginning of the year, it appears that your attitude towards math has become more (positive/negative). Would you say this is accurate? Can you explain why?
5. Do you have any other comments you would like to share?

## APPENDIX F

### End of Year Project Survey<sup>7</sup>

#### Community-Based Learning - Student Survey

I would like to better understand the impact that community-based learning has on students. I particularly want to know how this experience has influenced your perspective on learning and your view of service. Please take 5-10 minutes to complete this survey. Thank you.

Please respond to all statements on a 1-5 scale, with 1 being “Strongly Disagree” and 5 being “Strongly Agree”

1. The community participation aspect of this course helped me to see how the subject matter I learned can be used in everyday life.
2. The community work I did through this course helped me to better understand the course content.
3. I feel I would have learned more from this course if more time was spent in the classroom instead of doing community work.
4. The idea of combining work in the community with school coursework should be practiced in more classes.
5. I feel that the community work I did through this course benefited the community.
6. I felt a personal responsibility to meet the needs of the community partner of this course.
7. My interactions with the community partner enhanced my learning in this course.
8. The community work involved in this course made me more aware of my own biases and prejudices.
9. The work I performed in the community enhanced my ability to communicate in a "real world" setting.
10. The community aspect of this course helped me develop my problem-solving skills.
11. The other students in this class played an important role in my learning.
12. The service aspect of this course helped me develop a deeper appreciation for the course content.
13. Please use the space below to leave any additional comments that you would like to make in regards to the service component of this course.

---

<sup>7</sup> Modified from Gelmon (2001).

## APPENDIX G

### Student Handout: Project overview

#### **Service-Learning Partnership Agreement and Project Description**

2015-2016 Academic Year

Our school's AP Statistics classes and the partner organization are entering into a partnership to create service-learning experiences in the community. The following document will outline the planned project, the agreed upon responsibilities of all parties involved, and evaluation criteria.

#### **What is Service-Learning?**

Service-learning is a set of activities that 1) enhance either the delivery or the impact of the curricular material, and 2) take place within a service framework where additional experience with civic engagement or social contribution will be obtained.<sup>8</sup> Service-learning is more than community service performed by students (overemphasizing point 2) and at the same time service-learning also goes beyond simply real-world applications of course content (overemphasizing point 1). Rather, service-learning is meant to develop higher-order critical thinking in a real-world context while engaging students in an academic environment that portrays service as integral to the objectives of the course and the larger purposes of education.

#### **Service-Learning in the Context of AP Statistics**

The content of AP Statistics includes the following major topics:

- Exploratory Data Analysis: Planning a study, including deciding what to measure and measurement methods that minimize bias.
- Data Collection: Exploring and describing data by searching for quantifiable patterns and departures from patterns.
- Probability: Anticipating patterns, which include producing models using probability theory and exploration of distributions.
- Statistical inference: Includes developing confidence intervals and performing tests of significance.

As a service-learning project, students in AP Statistics at our school will work with the partner organization to complete survey research. Students will develop a survey instrument, conduct survey, compile and code data, analyze data, and present the results.

---

<sup>8</sup> Hadlock, C.R. (2005). "Introduction and Overview." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences*. Washington, DC: Mathematical Association of America.

This project will synthesize the major concepts of experimental design, data analysis, and statistical inference in the real-world context of community service.

### **The Mission of the Partner Organization**

The partner organization (PO) is a homeless outreach ministry in Texas. PO operates under a philosophy that homelessness is more than house-less-ness, it is rather a severe break in community from others. PO has acquired land just outside of the city on which they are currently developing a community of affordable housing for the chronically homeless, known as the property. The property also has amenities such as a gardening center, animals such as chickens and goats, a clinic, and a workshop for PO's microenterprise endeavors. Everything about the property is designed to foster a sense of complete community.

### **Project Overview with the Partner Organization**

PO will partner with the students in AP Statistics at our school to complete a study based largely on Bruce K. Alexander's "Rat Park" experiment.<sup>9</sup> Basically, seminal studies that had proven the addictiveness of drugs such as heroin (and others) had done so through administering the drug to rats in cages in isolation. Alexander set up a study in which the rats were allowed to operate in community and found that the amount of drugs consumed went down drastically, indicating that environment and community (or lack thereof) can play a significant role in drug use. PO is interested in seeing if the residents of the property will have the same response as the rats of "Rat Park."

PO is interested in having students survey the residents of the property on issues related to their life on the streets (physical, psychological, and spiritual) prior to moving to the new community and how those issues have changed since moving onto the property and into the community. So for instance, has the drug use among the occupants of the property significantly decreased in comparison to their life on the streets in isolation? With this basic premise, the students will be tasked with developing the complete survey, methodology, and appropriate analysis as part of the service-learning project.

### **Tentative Project Timeline**

- By September 1, 2015: agreement in place between PO and our school on the basic design, implementation, and evaluation of the project.
- Beginning of fall semester: students introduced to the notion of a service-learning project and the basic details of how they will be partnering with PO through the course syllabus.

---

<sup>9</sup> As referenced in Hari, J. (2015). *Chasing the scream: the first and last days of the war on drugs*. New York, NY: Bloomsbury, p. 170ff. See also: "The effect of housing and gender on Morphine self-administration in rats." *Psychopharmacology*. 58, pp. 175-179. and "Effect of early and later colony housing on oral ingestion of morphine by rats." *Pharmacology, Biochemistry, and Behaviour*, Vol. 15, pp. 571-576.

- October: representative(s) of PO will meet with students in person to give an overview of the mission and the property and the need they are interested in examining through this partnership.
- Middle of the fall semester (October – December): students design and pilot test a survey instrument.
- End of fall semester (December, 2015): students have a finalized survey instrument as well as a plan for sampling participants to gather data. A formal proposal will be written and submitted to Mr. Wilkerson as well as the PO representative.
- Beginning of spring semester (January/February, 2015): students collect data by interviewing the property residents.
- Middle of spring semester (around March, 2015): students work to analyze data under the supervision of Mr. Wilkerson as well as outside experts in the field.
- Late spring semester (April, 2015): Students finalize their findings and present results in a public setting to representatives from our school and PO.
- By May 1, 2015: all project details have been completed with the exception of post-project reflection exercises and evaluation.

### **Terms of Partnership Agreement**

The students agree to:

- Actively participate in acquiring knowledge about PO and its mission and orienting themselves to the history and purpose of the property development
- View the PO representative as a co-instructor for this portion of the course and the client to whom they are ultimately responsible to. Students will show PO representatives due respect at all times and in all forms of communication.
- Apply their knowledge of statistics to develop a survey instrument, conduct the survey, compile and code data, analyze data, and present the results in both oral and written form to representatives from PO.

The faculty representative, Mr. Josh Wilkerson, agrees to:

- Provide for the students an appropriate orientation to the community experience and learning goals of the project as well as ongoing support.
- Equip students with the necessary statistical skills for successfully completing the project in way that is meaningful to PO.
- Provide for PO appropriate background information on service-learning and the learning objectives of the course applied in the context of the project.
- Act as a facilitator in the relationship between the students and PO, ensuring that appropriate communication is occurring from both parties and that the project deadlines are met.
- Assess the students' attainment of learning objectives for the course and for the project.

The community partner, PO, representative agrees to:

- Provide appropriate orientation to PO and its mission through the property by meeting with the students in person prior to the start of the project
- Provide ongoing support to the students and faculty representative as needed through the course of the project.
- Facilitate access to the property residents for purposes of gathering survey data.
- Participate in the assessment of the students' effectiveness and the project's impact on PO and the property.

## Statistics Service Project Rubric – Fall Semester

<b>Journal Entries</b>	<b>25</b>	
Journal Entry 1	5	
Journal Entry 2	5	
Journal Entry 3	5	
Journal Entry 4	5	
Journal Entry 5	5	
<b>Survey</b>	<b>75</b>	
Draft 1 – Initial organization of questions	25	
Draft 2 – Refined questions and analysis of bias	25	
Final Draft – Piloted and edited	25	
<b>Written Proposal</b> (detailed rubric to be provided)	<b>100</b>	
Provides background on the partnering organization		
Clearly explains question of interest		
Explains the value of the study		
Methodology		
Timeline for spring implementation		
<b>Total</b>	<b>200</b>	



## Statistics Service Project Rubric – Spring Semester

<b>Journal Entries</b>	<b>100</b>	
Journal Entry 1 – Due 2/19	10	
Journal Entry 2 – Due 2/26	10	
Journal Entry 3 – Due 3/4	10	
Journal Entry 4 – Due 3/24	10	
Journal Entry 5 – Due 4/1	10	
Journal Entry 6 – Due 4/8	10	
Journal Entry 7 – Due 4/15	10	
Journal Entry 8 – Due 4/21	10	
Journal Entry 9 – Due 4/29	10	
Journal Entry 10 – Due 5/6	10	
<b>Written Proposal</b> (see detailed rubric)	<b>25</b>	
Due 3/4		
<b>Final Report</b> (see detailed rubric)	<b>75</b>	
Due 4/29		
<b>Total</b>	<b>200</b>	
<p>In addition to the written assignments submitted for grading (listed above), students are expected to participate in administering the survey at Community First (4/8) and in the presentation of project results (5/5).</p> <p>Please notify Mr. Wilkerson as soon as possible if you have a conflict with either of these dates.</p>		

<b>Project Calendar</b>	
<b>Date</b>	<b>Event</b>
September	Project Introduced
October	Experience in Surveying Initial meeting with Partnering Organization
December	Initial Proposal Submitted
January	Final Phase of Project Assigned <ul style="list-style-type: none"> <li>- Component Detailed Descriptions</li> <li>- Project Calendar</li> <li>- Grading Rubric</li> <li>- 12 Step Guide</li> <li>- Teamwork Rubric</li> </ul> Workday – Group Meetings with Mr. Wilkerson to revise proposals
February	Have a data collection time/date/place scheduled with organization
March	Deadline to have new proposal (and survey if giving one) approved
March/April	Workdays <ul style="list-style-type: none"> <li>- Bring laptop if wanting help on spreadsheet files</li> </ul>
End of April	Written Reports Due
End of April	Reports Returned with Feedback Final Workday
End of April	Presentations to Partnering Organization
<b>Beginning of May</b>	<b>ALL PROJECTS DONE</b> <b>REVIEW WEEK FOR AP EXAM 5/9</b>
Mid May	Self Reflection Assignment Due <ul style="list-style-type: none"> <li>- Details on this to follow</li> </ul>

## REFERENCES

- Anderson, L.W., & Krathwohl, D.R. (2000). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Pearson.
- Ankney, R. (2011). "Just Math: Learning about Justice with Math vs. Doing Justice with Math." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Arujo, C.R., Andrade, F., Hazin, I., Falcao, J.T.R., do Nascimento, J.C., & Lessa, M.M.L. (2003). Affective aspects on mathematics conceptualization: From dichotomies to an integrated approach. Paper presented at the 27th International Group for the Psychology of Mathematics Education Conference Held Jointly with the 25th PME-NA Conference (Honolulu, HI, Jul 13-18, 2003), v2, 269-276.
- Bailey, B. & Sinn, R. (2011). "Real Data & Service-learning Projects in Statistics." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Bargh, J.A., & Chartrand, T.L. (1999). The unbearable automaticity of being. *American Psychologist*, 54, 462-479.
- Barragán, J. (2015). Casualties of the streets. *Austin American Statesman*, November 13, 2015. Retrieved from <http://projects.statesman.com/news/homeless-deaths/>

- Berkove, E. (2013). "Service-learning in a capstone modeling course." *PRIMUS*, Vol. 23 (6), pp. 507-518.
- Black, K., Crisman, K., & Jardine, D. (2013). "Introductory editorial: special issue on service-learning." *PRIMUS*, Vol. 23 (6), pp. 497-499.
- Blitzer, R.F. (1977). The development and evaluation of an interdisciplinary cognitive-affective approach to general education mathematics. Unpublished doctoral dissertation. Nova University.
- Bloom, B.S., Englehart, M.D., Furst, E.J., Hill, W.H., & Krathwohl, D.R. (1956). *Taxonomy of educational objectives: Handbook I. Cognitive domain*. New York: McKay.
- Bonari, J.K. & Farrer, D.A. (2005). "Math carnivals: a celebration of mathematics." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Botella, J.M. (2012). Is there a relationship in primary education between affective factors in mathematics and academic performance? *Ese-estudios sobre education*, 23, 141-155.
- Brann, E. (2007). Are humans ultimately affective? *Expositions: Interdisciplinary Studies in the Humanities*, 1, 53-70.
- Bullock, A. (2012). *Real Austin: the homeless and the image of God*. Eugene, OR: Cascade Books.

- Carrigan, B., Carrigan, C., Kozak, B., & Rodger, C. (2011). "Northern Territory Maths Camp." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Chartier, T. (2011). "A Model for the Community." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Common Core State Standards Initiative (2016). Standards for Mathematical Practice. (<http://www.corestandards.org/Math/Practice/> accessed March 5, 2015).
- Cotic, M., & Zuljan, M.V. (2009). Problem-based instruction in mathematics and its impact on the cognitive results of the students and on affective-motivational aspects. *Educational Studies*, 35:3, 297-310.
- Craig, D. (2005). "Technology-college algebra service-learning project: 'surviving college algebra.'" In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Creswell, J. (1998). *Qualitative inquiry and research design*. Thousand Oaks, CA: SAGE.

- Crisman, K. (2011). "Mathematical and Moral Development Through Service-Learning." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Donnay, V.J. (2005). "Perspectives on education-oriented mathematics projects in a service-learning framework." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Duckworth, A. (2016). *Grit: The power of passion and perseverance*. Simon and Schuster.
- Duke, J.I. (1999). "Service-Learning: taking mathematics into the real world." *The Mathematics Teacher*, 92 (9), pp. 794-796, 799.
- Dweck, C. (2006). *Mindset: The new psychology of success*. Random House.
- Dwyer, J.F. (2005). "K-12 math tutoring as a service-learning experience for elementary education students." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Edwards, J. (2007). *A Treatise Concerning Religious Affections*. New York: Cosimo Classics.

- Engel, A., May, C.L., & O’Leary, M. (2005) “The Baltimore city fire department staffing problem.” In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Eyler, J., Giles, D. E., & Schmeide, A. (1996). A practitioner's guide to reflection in service-learning: Student voices & reflections. Vanderbilt University.
- Fennema, E., & Sherman, J.A. (1976). Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education*, 7, 324-326.
- Galluzzo, B. (2011). “Disaster Modeling – Beyond the Numbers.” Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through “Service-Learning and Mathematics” webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Gelmon, S. B. (2001). *Assessing service-learning and civic engagement: Principles and techniques*. Campus Compact, Brown University.
- Goldin, G. A. (2002). Affect, meta-affect, and mathematical belief structures. In *Beliefs: A hidden variable in mathematics education?* (pp. 59-72). Springer Netherlands.
- Goldin, G.A., & DeBellis, V.A. (2006). Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies in Mathematics*, 63:2, 131-147.
- Goldin, G.A. (2009). The affective domain and students’ mathematical inventiveness. In R. Leikin, A. Berman, & B. Koichu (Eds.), *Creativity in mathematics and the education of gifted Students*. Rotterdam: Sense Publishers, pp. 181-194.

- Goldin, G. A. (2014). Perspectives on emotion in mathematical engagement, learning, and problem solving. . In R. Pekrun & L. Linnenbrink Garcia (Eds.), *Handbook of emotions in education* (pp. 391-414). New York, NY: Taylor & Francis.
- Gómez-Chacón, I.M. (2000). Affective influences in the knowledge of mathematics. *Educational studies in Mathematics*, 43, 149-168.
- Gómez-Chacón, I. M., & Haines, C. (2008). Students' attitudes to mathematics and technology. Comparative study between the United Kingdom and Spain. In *International Congress on Mathematical Education* (pp. 1-12).
- Gresalfi, M. S., & Cobb, P. (2006). Cultivating students' discipline-specific dispositions as a critical goal for pedagogy and equity. *Pedagogies*, 1, 49–58.
- Grinshpan, A.Z. (2005). "The mathematics umbrella: modeling and education." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Hadlock, C.R. (2005a). "Introduction and Overview." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Hadlock, C.R. (2005b). "Untapped possibilities?" In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.



- Hadlock, C. (2011). "Opportunities and Challenges in Incorporating Service-Learning in Mathematical Science Programs." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Hadlock, C.R. (2013). "Service-learning in the mathematical sciences." *PRIMUS*, Vol. 23 (6), pp. 500-506.
- Haladyna, T., Shaughnessy, J., & Shaughnessy, J.M. (1983) A causal analysis of attitude toward mathematics. *Journal for Research in Mathematics Education*, 14, 19-29.
- Hall, R. and Moore, D. (2013). *Same kind of different as me: conversation guide*. Nashville, TN: Thomas Nelson.
- Hamman, J.F. (2005). "Service-learning for pre-service teachers and developmental math students." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Hannula, M.S. (2006). Motivation in mathematics: Goals reflected in emotions. *Educational Studies in Mathematics*, 63, 165-178.
- Hari, J. (2015). *Chasing the scream: the first and last days of the war on drugs*. New York, NY: Bloomsbury.
- Heidegger, M. (1966). *Being and Time*, trans. John Macquarrie and Edward Robinson. New York: Harper & Row.

- Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880.
- Hunter, K. (2017, January). *Empathy in Education: Resources*. Retrieved from [http://empathyed.org/index.php?option=com\\_content&view=article&id=54&Itemid=69](http://empathyed.org/index.php?option=com_content&view=article&id=54&Itemid=69)
- Hydorn, D.L. (2005). "Community service projects in a first statistics course." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Hydorn, D. (2011). "Community Service-Learning in Mathematics: Models for Course Design." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Jansen, A. (2012). Developing productive dispositions during small group work in two sixth grade mathematics classrooms: Teachers' facilitation efforts and students' self reported benefits. *Middle Grades Research Journal, 7*(1), 37-56.
- Klanderman, D., Moore, M.W., Maxwell, M.S., & Robbert, S.K. (2013). "Creating problems and their solutions: service-learning through Trinity mathematics triathlons, math nights, and math centers." *PRIMUS, Vol. 23* (6), pp. 563-571.
- Krathwohl, D.R., Bloom, B.S., & Masia, B.B. (1964). *Taxonomy of educational objectives: Handbook II. Affective Domain*. New York: Longman.

Larsen, J. (2013). "Attitude in mathematics: a thematic literature review." [http://judy-larsen.weebly.com/uploads/1/7/7/5/17756331/attitude\\_literature\\_review\\_-\\_larsen.pdf](http://judy-larsen.weebly.com/uploads/1/7/7/5/17756331/attitude_literature_review_-_larsen.pdf), accessed June 24, 2015.

Lebens, M., Graff, M., & Maye, P. (2011). The affective dimensions of mathematical difficulties in schoolchildren. *Education Research International*, 2011, 1-13.

Leder, G.C., Pehkonen, E., & Törner, G. (2002). *Beliefs: a hidden variable in mathematics education?* Boston: Kluwer Academic Publishers.

Leong, J. (2006). High school students' attitudes and beliefs regarding statistics in a service-learning-based statistics course. Unpublished doctoral dissertation. Georgia State University.

Ma, X. (2006). Cognitive and affective changes as determinants for taking advanced mathematics courses in high school. *American journal of education*, 113, 123-149.

Maaz, J., & Schölglmann, W. (2009). *Beliefs and attitudes in mathematics education: new research results*. Rotterdam: Sense publishers.

Malmivouri, M.L. (2001). The dynamics of affect, cognition, and social environment in the regulation of personal learning processes: The case of mathematics. Unpublished doctoral dissertation. University of Helsinki.

Malmivouri, M.L. (2006). Affect and self-regulation. *Educational studies in mathematics*, 63, 149-164.

- Massey, M. (2005). "Service-learning projects in data interpretation." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- McCloskey, A. (2014). The promise of ritual: a lens for understanding persistent practices in mathematics classrooms. *Educational Studies in Mathematics*, 86(1), 19-38.
- McDowell, L.G. (2005). "Connecting mathematics to real-world classrooms." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- McKelvey, S. (2005). "Real world consulting: the Saint Olaf mathematics practicum." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- McLeod, D.B. (1988). Affective issues in mathematical problem solving: Some theoretical considerations. *Journal for Research in Mathematics Education*, 19, 134-141.
- McLeod, D.B. (1989a). Beliefs, Attitudes, and Emotions: New Views of Affect in Mathematics Education. In D.B. McLeod & V.M. Adams (Eds.), *Affect and mathematical problem solving. A new perspective* (pp. 245-258). New York: Springer-Verlag.

- McLeod, D.B. (1989b). The role of affect in mathematical problem solving. In D.B. McLeod & V.M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 220-234). New York: Springer-Verlag.
- McLeod, D.B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575-596). New York: Macmillan.
- McLeod, D.B. (1994). Research on affect and mathematics learning in the JRME: 1970 to Present. *Journal for Research in Mathematics Education*, 25(6), 637-647.
- Morse, J. & Sabloff, J. (2005). "The community math teaching project." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Mulhern, F. & Rae, G. (1998). Development of a Shortened Form of the Fennema-Sherman Mathematics Attitudes Scales. *Educational and Psychological Measurement*. 58(2), 295–306.
- Myers, P. (2005). "Family math nights: sharing our passion for mathematics." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: NCTM.

- National Council of Teachers of Mathematics. (1991). Standards for teaching mathematics. Reston, VA: NCTM (<http://www.fayar.net/east/teacher.web/math/standards/previous/ProfStds/TeachMath.htm> accessed April 25, 2015).
- National Council of Teachers of Mathematics. (1995). Mathematics Assessment Standards. Reston, VA: NCTM.
- National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. Reston, VA: NCTM (<http://www.nctm.org/Standards-and-Positions/Principles-and-Standards/> accessed January 19, 2016).
- National Research Council (1989). *Everybody counts: A report to the nation on the future of mathematics education*. Washington D.C.: National Academy Press.
- National Research Council (2001). *Adding it up: Helping children learn mathematics*. Washington D.C.: National Academy Press.
- Ng, P.H. (2005). "Designing efficient snow plow routes: a service-learning project." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oak, CA: Sage.
- Prawat, R.S., & Anderson, A.L.H. (1994). The affective experience of children during mathematics. *Journal of mathematical behavior*, 13:2, 201-221.
- Radu, P. (2013). "Taking math outside of the classroom: math in the city." *PRIMUS*, Vol. 23 (6), pp. 538-549.

- Ramsay, J.R. (2005). "Creating experience in an experimental learning environment." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Reed, G. (2005). "Perspectives on statistics projects in a service-learning framework." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Ridlon, C. (2005). "America counts: a tutoring program for the twenty-first century." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Ritter-Smith, K. & Saltmarsh, J. (1998). *When community enters the equation: enhancing science, mathematics, and engineering education through service-learning*. Campus Compact.
- Roberts, C.A. (2005). "Perspectives on modeling applications in a service-learning framework." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Roemer, C.A. (2009). Service-learning and mathematics. Unpublished doctoral dissertation. Teachers College, Columbia University.

- Root, R., Thorne, T., & Gray, C. (2005). "Making meaning, applying statistics." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Schorr, R. & Goldin, G. (2008). "Students' expression of affect in an inner-city simcalc classroom." *Educational Studies in Mathematics*, Vol. 68 (3), pp. 131-148.
- Schulteis, M.S. (2013). "Serving Hope: building service-learning into a non-major mathematics course to benefit the local community." *PRIMUS*, Vol. 23 (6), pp. 572-584.
- Sfard, A. (2008). *Thinking as communicating. Human development, the growth of discourses, and mathematizing*. Cambridge, New York: Cambridge University Press.
- Shafii-Mousavi, M. & Kochanowski, P. (2011). "Service-Learning in an Interdisciplinary Mathematics and Economics Course." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Sinclair, N. (2006). *Mathematics and beauty: Aesthetic approaches to teaching children*. New York: teachers College Press.
- Smith, C. (2003). *Moral, Believing Animals*. Oxford: Oxford University Press.
- Smith, J.K.A. (2009). *Desiring the kingdom: Worship, worldview, and cultural formation*. Grand Rapids, MI: Baker Academic.
- Stake, R.E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.



- Stanish, K. (2011). "Serve While You Learn: A Quantitative Literacy Course." Service-learning in collegiate mathematics, MAA contributed paper session, 2011 Joint Mathematics Meetings, New Orleans, LA. Accessed through "Service-Learning and Mathematics" webpage: <http://www.math-cs.gordon.edu/~kcrisman/SLTalks/>
- Sungur, E.A., Anderson, J.E., & Winchester, B.S. (2005). "Integration of service-learning into statistics education." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Taylor, C. (2004). *Modern social imaginaries*. Durham, NC: Duke University Press.
- Taylor, J., & Galligan, L. (2006). Mathematics for the maths anxious tertiary students: Integrating the cognitive and affective domains using interactive multimedia. *Literacy & numeracy studies*, 15:1, 23-43.
- Thomas, D., & Brown, J. S. (2007). The play of imagination: Extending the literary mind. *Games and Culture*, 2(2), 149–172.
- Veatch, M. (2001). Mathematics and values. In R. Howell & J. Bradley (Eds.), *Mathematics in a Postmodern Age: A Christian Perspective*. Grand Rapids: Eerdmans, pp. 223-249.
- Webster, J. & Vinsonhaler, C. (2005). "Getting down to work – a 'how-to' guide for designing and teaching a service-learning course." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.

- Williams, S.R., & Ivey, K.M.C. (2001). Affective assessment and mathematics classroom engagement: A case study. *Educational Studies in Mathematics*, 47, 75-100.
- Wilson, P. (2011). Disposition towards engagement in mathematics. *Proceedings of the British Society for Research into Learning Mathematics*, 31(June), 67-72. Retrieved from <http://www.bsrlm.org.uk/IPs/ip31-2/BSRLM-IP-31-2-12.pdf>
- Wilson, T.D. (2004). *Strangers to ourselves: Discovering the Adaptive Unconscious*. Boston: Harvard University Press.
- Yeager, D., Walton, G., & Cohen, G. L. (2013). Addressing achievement gaps with psychological interventions. *Phi Delta Kappan*, 94(5), 62-65.
- Zan, R., Brown, L., Evans, J., & Hannula, M.S. (2006). Affect in mathematics education: An introduction. *Educational Studies in Mathematics (Affect in Mathematics Education: Exploring Theoretical Frameworks: A PME Special Issue)*, 63:2, 113-121.
- Zang, R.A. (2005). "Can we teach social responsibility? Finite mathematics students at an urban campus tutor at-risk youth." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.
- Zlotkowski, E. (2005). "Foreward." In C.R. Hadlock (Ed.), *Mathematics in service to the community: Concepts and models for service-learning in the mathematical sciences* (No. 66). Mathematical Association of America.