

## Cultivating Mathematical Affections through Engagement in Service-Learning

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### 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.

"When am I ever going to use this?" is probably the most common statement uttered in a mathematics class. Please notice that I referred to this as a *statement* and not as a *question*. 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. 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?" In his *Confessions*, St. Augustine states "You have made us for yourself, O Lord, and our heart is restless until it rests in you." As Christians we of all people should realize that statement does not stop being true when students walk into math class. Even (or perhaps especially) in math class, students desire to find value (through content/application) and to be valued (through pedagogy). While the utility of mathematical concepts is certainly important, we as mathematics educators, and especially as Christian educators, need to utilize the mathematics classroom to address the more fundamental issue of fostering a proper sense of values.

Affective/value 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), the basis for the modern Common Core State Standards Initiative (2016), 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 the valuation of mathematics must lead to a habit of seeing mathematics as worthwhile. This definition of productive disposition is a clear example of an affective objective for students of mathematics, yet it contains no supporting information on how to practically reach the objective.

The purpose of this case study was to analyze the role of service-learning in the cultivation of a productive disposition for students in a statistics class as they participated in a service-learning project addressing chronic homelessness. Service-learning was examined as a potential pedagogical tool that can be utilized to develop a habitual inclination to see mathematics as worthwhile. The issue at hand is whether service-learning offers a vehicle for *how* to go about instilling the values that the math education desires to see in its students. The study sought to answer the following two research questions: (1) To what extent does service-learning impact the cultivation of a productive disposition among students? and (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?

## 1 Framework

The theoretical framework of this study builds primarily off of the work of philosopher James K.A. Smith (2009). 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.

The importance of affect and its positive development through habits, practices, and routines 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” (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). McCloskey (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 et al., 2010).

Hadlock (2005) stresses the importance of regular (habitual) practices of reflection throughout service-learning activities. Service-learning in its most effective and well-developed sense involves a multilayered reflection process that 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). The reflective process is vital for students to gain the most from a service-learning experience (Webster & Vinsonhaler, 2005, p. 257). Combining Smith’s view on rituals 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. 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. As will be described below, all students in the course participated in a weekly reflection journal component of a service-learning project throughout the course of the entire year.

The conceptual framework of this study centered on the description of “productive disposition” offered by the National Research Council. The collected data was 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.

## **2 Methodology**

This study was conducted as a qualitative case study, focusing on a select group of five students in a statistics class as they engaged in a service-learning project. 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 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) prior to the assignment of the service-learning project. From the responses to the FSMAS, a small group of five students was identified to be the members of the case study. The following variables were considered when selecting the group of five 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.

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, were also documented. 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 observational 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. The interview protocol was shaped based upon prior student interviews over a service-learning project from a 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.

The partner organization (henceforth referenced as “PO”) that students worked with on their service-learning project is a homeless outreach program in a central Texas city. PO operates under a philosophy that homelessness is more than house-less-ness, rather it is a severe break in community from others. PO 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, 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 PO was interested in joining with the students in the statistics course to complete a study based largely on Bruce K. Alexander's "Rat Park" experiment (as referenced in Hari, 2015, p. 170ff). Seminal studies that had proven the addictiveness of drugs such as heroin 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 was interested in having students survey the residents of their new community development on issues related to their life on the streets (physical, psychological, and spiritual) prior to moving to the new community and how those issues may have changed since moving to the community. With this basic premise, the students were tasked with developing the complete survey, methodology, and appropriate analysis as part of the service-learning project.

### **3 Results**

Below, Table 1 summarizes the research questions of this study and the manner in which data was collected and analyzed to assess the outcomes of this project.

#### **3.1 Quantitative Results**

At the end of the year, all students ( $N = 39$ ) in the course completed a community based service survey in which they responded to statements about the project on a Likert scale. The responses from the statements related to seeing math as sensible, useful, and worthwhile were 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. The results are shown in figure 1 below:

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. 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. A t-test was run against a null hypothesis of  $\mu = 10$ , the t value was 2.32 and the  $p$ -value is 0.01297, indicating significant evidence that the true mean disposition is greater than 10.

#### **3.2 Qualitative Results on Productive Disposition**

##### **Research Question 1**

Service-learning appeared to have a positive effect on students' valuation of 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. Table 2 summarizes the levels of Krathwohl's affective domain (Krathwohl, 1964) and the terms/concepts that

Research Question	Variable	Indicators	Measurement
To what extent does service-learning impact the cultivation of a productive disposition 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 Observations
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

Table 1: Questions and Data Collection

were used by students that were coded to correspond to each level.

One example of student responses and the corresponding association with advancement in Krathwohl's taxonomy comes from Tabitha (pseudonym). 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

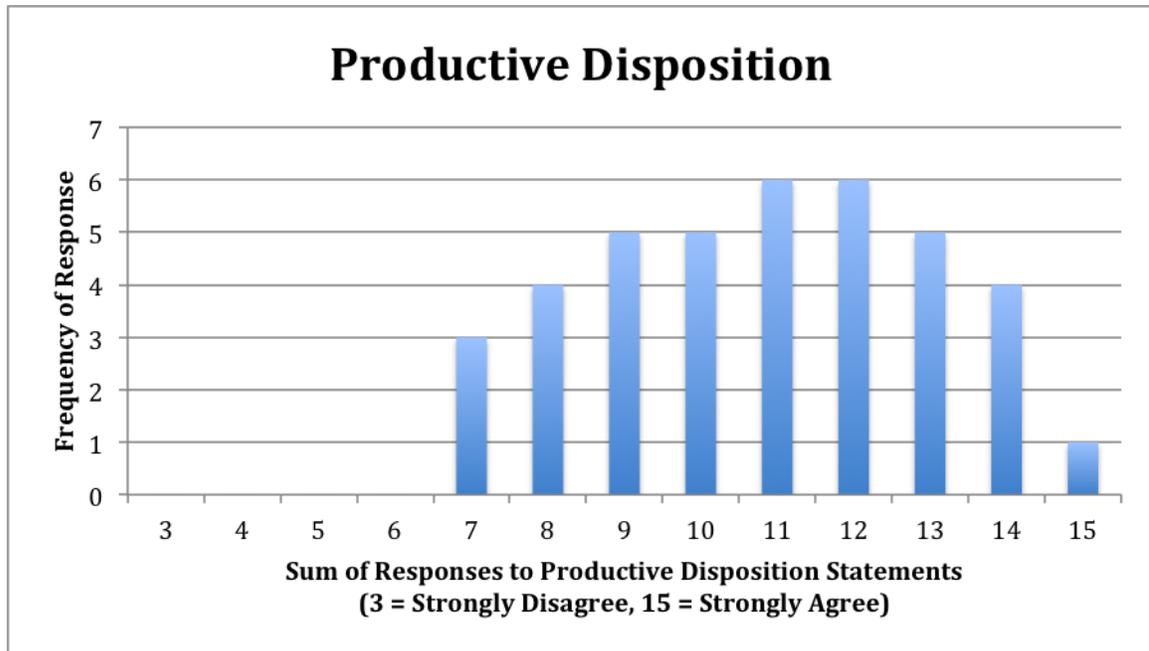


Figure 1: Community service survey responses related to disposition

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.

Another student, Charlotte, indicated 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 it she thought it was reasonable to say that her attitude towards

		Krathwohl's Affective Domain	Summary of domain category	Associated Verbs for Student Learning Objectives	Terms, concepts, descriptors used by students and coded:
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	Comments on change of perspective on mathematics in a service context
		Organizing	bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system	Discuss, theorize, formulate, balance, prioritize	Comments on conflicts with prior negative experiences
Valuing		the worth or value a student attaches to a particular object, phenomenon, or behavior	Measure proficiency, subsidize, support, debate	Important, good, having meaning, fulfilling	
Responding		active participation on the part of the student	Comply, follow, commend, volunteer, acclaim, engage in	Invested, rewarding	
Values Instilled in Students		Receiving	student's willingness to attend to particular phenomena of stimuli	Differentiate, accept, listen for, respond to	Cool, fun, exciting, admirable

Table 2: Responses and Advancement

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. 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 [students designed an awning for an RV park being used as affordable housing], 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.

Overall, the five students in the case study seemed to regularly reach the *organizing* stage of Krathwohl's affective domain. The students also regularly attributed the method by which they reached the *organizing* stage to a change in the routine of the mathematics class - from the expected lecture-practice-assess cycle to breaking for periods of application and reflection. 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**

For the five students in case study the 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. While these terms have quite a bit of overlap in their usage (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.

Each student in the case study was able to articulate, in his or her own unique way, their understanding of mathematics as sensible, useful, and worthwhile. Through the project each student was able to articulate the sensibleness of the course material, how the math he/she was learning was useful in his/her immediate context, and the rewarding nature of the work and effort the student contributed.

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? 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.

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 be 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.

What follows is an extended analysis of one student, Charlotte, to indicate how student responses were coded and analyzed to see growth in productive disposition. 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 the service-learning project influenced her change to a more positive view of mathematics. 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 ministry 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.

The final student, 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 greatly valued forming relationships with others. While only 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.

## 4 Conclusions

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. 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.

## References

- Common Core State Standards Initiative (2016). Standards for Mathematical Practice. <http://www.corestandards.org/Math/Practice/>. Accessed 12 April 2018.
- 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.
- Goldin, G. A. (2002). Affect, meta-affect, and mathematical belief structures. In *Beliefs: A hidden variable in mathematics education?* (pp. 59-72). Springer Netherlands.

- Gresalfi, M. S., & Cobb, P. (2006). Cultivating students' discipline-specific dispositions as a critical goal for pedagogy and equity. *Pedagogies*, 1, 49-58.
- 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.
- Hari, J. (2015). *Chasing the scream: the first and last days of the war on drugs*. New York, NY: Bloomsbury.
- 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).
- 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.
- Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). *Taxonomy of educational objectives: Handbook II. Affective Domain*. New York: Longman.
- McCloskey, A. (2014). The promise of ritual: a lens for understanding persistent practices in mathematics classrooms. *Educational Studies in Mathematics*, 86(1), 19-38.
- 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.
- National Council of Teachers of Mathematics. (1991). *Standards for teaching mathematics*. Reston, VA: NCTM
- National Research Council (2001). *Adding it up: Helping children learn mathematics*. Washington D.C.: National Academy Press.
- 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.
- Smith, J.K.A. (2009). *Desiring the kingdom: Worship, worldview, and cultural formation*. Grand Rapids, MI: Baker Academic.
- Thomas, D., & Brown, J. S. (2007). The play of imagination: Extending the literary mind. *Games and Culture*, 2(2), 149-172.
- 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.
- 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.