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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.

1. Perspectives and Framework for the Research

1. 1. Purpose of the Research

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.

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.

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 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?

1.2. 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.

1.3. Conceptual Framework

The conceptual framework of this study centered 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 focused 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 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.

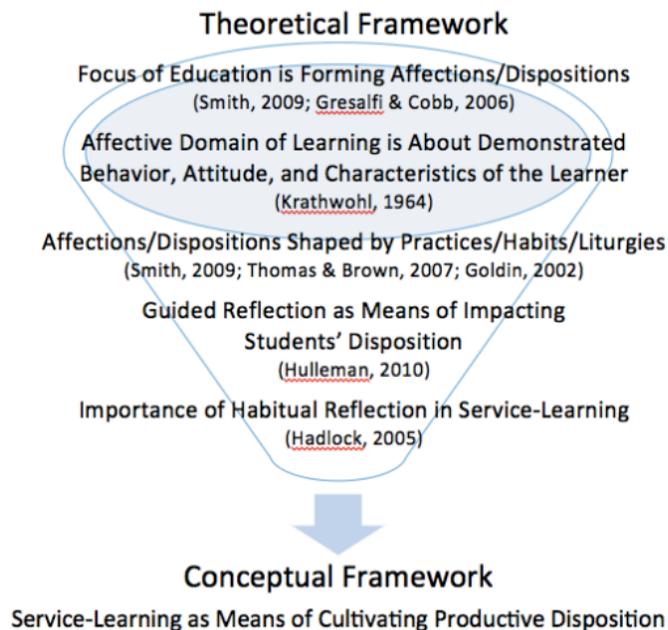


Figure 1: Theoretical and Conceptual Framework

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), included in Appendix A, 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 (see Appendix B). 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.

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.

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).¹ Seminal studies that had proven the addictiveness of drugs such as heroin had done so through administering the drug to rats

¹ 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.

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.

Research Question	Variable	Indicators	Measurement
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"> • Role of community experience in learning • Role of community experience in engagement • Changes in perspective on course content 	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"> • Role of community experience in understanding course content • Perceived relevance of community experience to course content 	Interviews Surveys Reflection Journals Observed interactions with students and instructor
	Applying course content (Useful)	<ul style="list-style-type: none"> • Role of community experience in applying course content • Recognition of practical application of course content 	Interviews Surveys Reflection Journals Observed interactions with community partner
	Valuing course content (Worthwhile)	<ul style="list-style-type: none"> • Role of community experience in producing a rewarding sense of work committed to course content • Recognition of community experience to sufficiently important to justify effort spent 	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"> • Recommendation to utilize community experience in other courses • Valuing time spent on community experience over against traditional methods of learning • Drawbacks of community experience 	Interviews Surveys

Table 1

3. Results

3.1. Results for Research Question 1

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 2.

	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	

Table 2

When Tabitha (pseudonym) 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.

3.2. Results for Research Question 2

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?

3.2.1. 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:

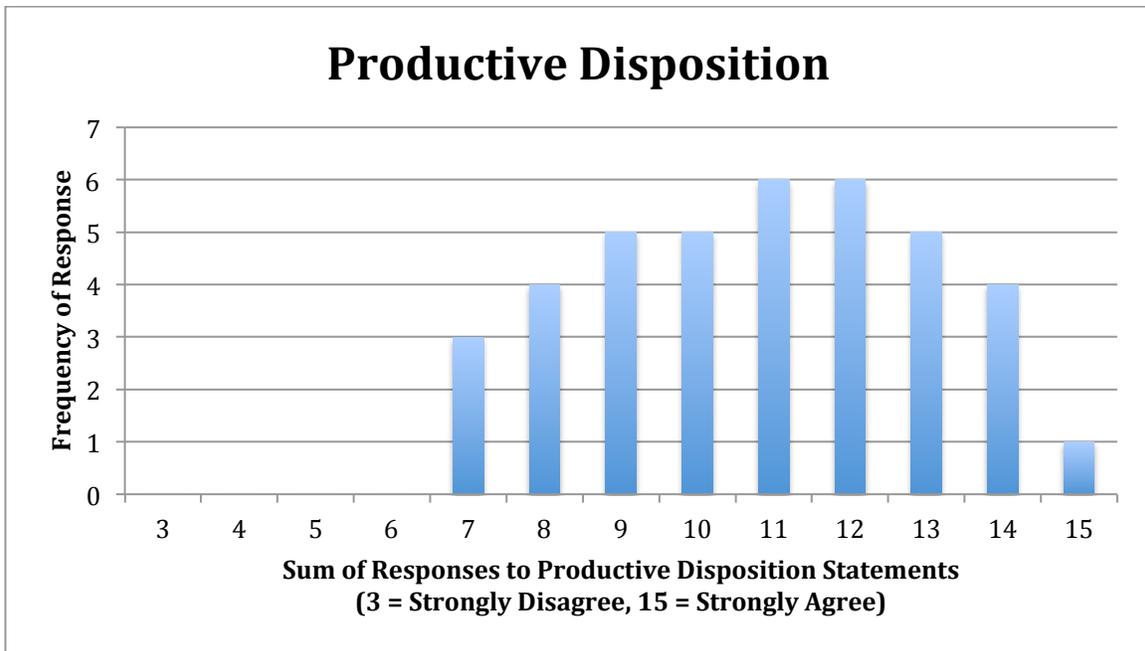


Figure 1: Community service survey responses related to disposition

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. 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.

Students were also given an end-of-the-year survey on community-based learning and the results are summarized in Table 3.

1. The community participation aspect of this course helped me to see how the subject matter I learned can be used in everyday life.				
$\bar{x} =$	$s =$	$t =$	p -value (to 3 decimals)	Significant at $\alpha = .05$?
4.025	0.83	7.79	0.000	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

Table 3

3.2.2. Qualitative Results

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.

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.

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 A

Modified Fennema-Sherman Math Attitudes Scale²

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

² 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

Observation Protocol and Sample Documentation

Last day prior to 2 week break

VP study found in proposal

Spring Observation 4
Proposal Workday

C Block 9:35-9:55

Friday 3/4/16

may already be done (most likely)

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	Computer out reference project documents	TR asks question of others to clarify steps	CW asks question about unit terminology		AB writing on paper (different assignment)	MB talks in group off to pic	
CW focused look at computer X2	CW computer out activity 6 X2	CW asks students about unit for notes	TR asks several questions about format of content			MB laughs in group of boys at computer screen	
TR focused on reading project files	CW sits by id for couch to friends X4	TR asks student how long period there	CW asks about unit notes/terms			CW talking with students about Euro trip	
CW focused on reading projects	MB computer out 7ps	TR asking student questions				X2	
CW focused on notes X2	X4		TR question on spelling terminology			TR asks students about unit assignment	
	TR typing (in midst of student pouring drinks)		TR asks question about variability reduction in method			TR responds to question of going by tomorrow	
	CW head in hair, scratches head, looks at computer screen					CW stepping on my back to seat to talk to another student	

very clear - TR/CW - tasks involved
- VP done
- AB done most likely
- MB off to pic

AB talks to other students off to pic X4

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