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Reducing Math Anxiety: Findings from Incorporating Service Learning into a Quantitative Reasoning Course at Seattle University

Allison Henrich

Seattle University, henricha@seattleu.edu

Kristi Lee

Seattle University, leekrist@seattleu.edu

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Reducing Math Anxiety: Findings from Incorporating Service Learning into a Quantitative Reasoning Course at Seattle University

Abstract

How might one teach mathematics to math-anxious students and at the same time reduce their math anxiety? This paper describes what we found when we incorporated a service learning component into a quantitative reasoning course at Seattle University in Fall 2010 (20 students) and Spring 2011 (28 students). The course is taken primarily by humanities majors, many of whom would not take a course in math if they didn't need to satisfy the university's core requirement. For the service learning component, each student met with and tutored children at local schools for 1-2 hours per week (total about 15 service hours), kept a weekly journal reflecting on the experience, and wrote a five-page final paper on the importance and reasonable expectations of mathematics literacy. The autobiographies, self-description at the beginning of the class, focus group interviews at the end of the term, journal entries, final essays, and student evaluations indicated that the students gained confidence in their mathematical abilities, a greater interest in mathematics, and a broader sense of the importance of math literacy in modern society. One notable finding was that students discovered that the act of manufacturing enthusiasm about math as a tool for tutoring the children made them more enthusiastic about math in their own courses.

Keywords

service learning, quantitative reasoning, math anxiety

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Cover Page Footnote

Allison Henrich is an Assistant Professor of Mathematics at Seattle University. She is interested in studying barriers to students' achievement of appropriate levels of mathematical competency both in the humanities and in the sciences. She hopes to work with others in the mathematics and education communities to develop methods for breaking down these barriers. Her primary mathematics research interests are in low-dimensional topology.

Kristi A. Lee is an Assistant Professor of Community Counseling at Seattle University. She studies how the use of service learning in higher education can contribute both to college student learning and to the building of mutually beneficial relationships between university and community life. Specifically, she is interested in promoting a more just and humane world through community engagement and service learning.

Introduction

Math Anxiety

Many students, particularly non-math majors, come to college math classes with high levels of math-related anxiety (Royse and Rompf 1992; Fiore 1999; Connor 2008). Yet they are often required by their institutions of higher education to take math classes for graduation. This scenario presents a challenge for math educators who are charged with improving math literacy and quantitative reasoning abilities in their students. How do math educators teach anxious students while seeking to reduce their anxiety levels?

According to Perry (2004), math anxiety is a common experience among students in higher education. Math anxiety has been defined as an “inability by an otherwise intelligent person to cope with quantification, and more generally mathematics.... When confronted with a math problem, the sufferer has sweaty palms, is nauseous, has heart palpitations, and experiences paralysis of thought...” (Krantz 1999). Tobias and Wiessbrod (1980) report that people with math anxiety experience panic, helplessness, and mental disorganization when required to engage with math problems. As many as 85% of students in one math educator’s introductory mathematics courses report at least mild levels of math-related anxiety (Perry 2004).

Math anxiety can begin early in life and persist throughout adulthood. The causes of math anxiety are varied and are more likely to be acquired rather than inherited (Royse and Rompf 1992). Possible causes of math anxiety include having an insensitive or incompetent math teacher in the past, student fear of failure or a sense of inadequacy, inability to handle frustration, poor pre-college math preparation, and low math achievement (Royse and Rompf 1992; Fiore 1999; Perry 2004). Parental messages to students about math and the students’ abilities are also contributing factors (Fiore 1999). In addition, negative messages about abilities in math may be related to gender, with women often having lower levels of perceived competence in math (Tobias 1993).

The development of math anxiety in students has potentially serious consequences. Students with math anxiety will likely avoid careers that require math and will have decreased desire to enroll in math classes (Metie, Frank, and Croft 2007; Connor 2008). The likely outcome is that students will take the minimum number of math classes required to graduate. Therefore, college graduates may have lower levels of quantitative literacy in adulthood. This appears to be particularly true for women who have been historically tracked into majors that do not require math, such as the humanities and education. Students who avoid math classes render themselves incapable of majoring in host fields

like engineering, the sciences, and math itself, thus limiting their future professional options (Tobias 1993).

Metie et al. (2007) state that helping students work through their math anxiety is a significant challenge for math educators. If math educators consider and address math anxiety as they design and deliver their classes, this problem might be mitigated. If students have developed math anxiety as a result of negative experiences with traditional teaching methods (i.e., classroom lectures), introducing new teaching methods may be one approach for reducing math anxiety. The authors of this paper were interested in the impact on students suffering from math anxiety of taking a quantitative reasoning course with a service learning component.

Service Learning

Service learning is a teaching method that integrates academic content with active service to the community (Kezar and Rhoads 2001; Kronick 2007). Students who engage in service learning apply their learning to community needs and, in doing so, show both increased understanding of classroom content and a greater sense of connection to their communities (Eyler, Root, and Giles 1998; Strage 2000).

As a distinct teaching method, service learning has six components that separate it from other approaches. First, service learning occurs in a specific educational context or *academic house*. The service experiences are specifically selected to expand academic learning and are directly related to the course material. Second, *student voice* is incorporated into the service learning experiences. Students actively participate in selecting and designing service learning projects to the greatest degree possible. This active engagement has increased student participation and results in more positive outcomes (Warter and Grossman 2002). Third, service learning is facilitated in part by *community partnerships*. These are individuals and organizations that provide opportunities for students to carry out service learning (Warter and Grossman 2002). They may include non-profit organizations, schools, or community support groups. Fourth, the service learning seeks to help meet a *community 'felt need.'* Service projects flow out of an understanding of the community needs articulated by the community (Exley 2004). If those in academia assume to know what is best for a community, harm may occur to the community through disempowerment and marginalization (Exley 2004). Fifth, course instructors engage their students in *guided reflection* as a way to help them make meaning of their service experiences and to deepen their academic learning. Reflection provides opportunities to help students make connections between course curriculum and service experiences (Warter and Grossman 2002). Finally, in order to determine the impact of the service learning experiences, instructors conduct *meaningful evaluation*, including assessing the benefit and impact of the service from the

students' perspectives as well as the community partners (Ward and Wolf-Wendel 2000).

Studies on the impact of service learning in higher education have shown promising findings. One large study found that service learning increased student motivation for course involvement, deepened understanding of course content, improved learning, enhanced critical-thinking and problem-solving skills, and strengthened social responsibility (Eyler and Giles 1999, as reported in Connor 2008). Connor (2008) conducted a study in which college students with math anxiety engaged in service learning in the context of a math methods course for pre-service teachers. The service learning projects included developing math lessons for a local elementary school that had requested assistance. At the conclusion of the course, students scored significantly lower on the Mathematics Anxiety Rating Scale of Adults (Richardson and Suinn 1972) than they had at the beginning of the course.

Another study utilized service learning in a discrete math class for liberal arts majors (Zang, Gutmann, and Berk 2000). Students were offered the opportunity to tutor teenagers preparing for their GED high school equivalency exam. Six students participated in service learning, and three of these students were interviewed and surveyed about the experience. At the end of the course, the students indicated that they not only had a better understanding of what it means to be socially responsible, but they also reported reduced levels of math anxiety.

The results of these studies suggest that, in addition to promoting other positive outcomes, service learning in a non-majors math course can reduce math anxiety. The remainder of this paper will describe the way a quantitative reasoning course, previously taught using traditional methods, was designed with a service learning component. The quantitative reasoning with service learning course was taught at Seattle University, a small, private university in the northwestern United States. Evaluation of the service learning course will follow the course description.

The Course

Students who take a quantitative reasoning course at Seattle University are typically humanities majors who are required to take the course to satisfy a core requirement. It is clear from talking to them that most of these students would avoid taking any math course in college were it an option for them to skip the requirement. While there is currently no official prerequisite for the course, a basic knowledge of high school algebra and geometry is assumed.

The primary goals of the course, as stated in the syllabus, are to develop basic mathematical skills needed for lifetime proficiency (such as the ability to organize qualitative information, estimate quantities, interpret and draw graphs, understand

and compute ratios, percentages and proportions); to recognize when mathematical tools are appropriate for solving both real-world and abstract mathematical problems, and gain confidence in solving such problems; to enjoy learning about mathematics; and to critically assess the value of and barriers to gaining mathematical literacy. Aside from the last goal in the list, these goals are shared by all quantitative reasoning courses at Seattle University.

Typical quantitative reasoning (QR) courses at the authors' institution have similar goals and, in general, look very similar to QR, Discrete Math or Math for Liberal Arts courses at many other colleges and universities. Topics may include voting theory, basic statistics and statistical data collection, probability theory, graph theory, games and puzzles, financial math, logic, Fibonacci numbers and the golden ratio, and exponential growth. Seattle University's mathematics department has been using Peter Tannenbaum's *Excursions in Modern Mathematics* (2010) for the past several years. This type of course usually meets for ten weeks, one hour each day, four days a week for a total of four hours a week.

While many of the professors teaching QR courses at our institution require students to write a math autobiography at the start of the term, this is often the extent of written self-reflection in our quantitative reasoning courses. Before the service learning experiment that was undertaken this year, service learning was never incorporated into our course. It was also uncommon for journals, readings and discussions centered on math literacy issues to be incorporated.

The instructor taught the QR course with service learning twice this academic year, one section in Fall Quarter 2010 and one section in Winter Quarter 2011. This year was the instructor's first time teaching this course. Both courses were taught using *Excursions in Modern Mathematics* (Tannenbaum 2010). In the fall, the course had 20 students (14 women, 6 men; 5 students of color) and met four days a week for an hour each day. In the winter quarter, there were 28 students in the course (16 women, 12 men; 4 students of color). This second iteration of the course met twice a week for two hours each class period.

Topics in the fall course included voting theory, graph theory, Fibonacci numbers and the golden ratio, financial math, statistical data collection, and basic statistics. Voting and graph theory were included as fun topics that served to dispel common misconceptions about the scope of mathematics, while Fibonacci numbers and the golden ratio served the same function and provided a framework for review of algebra and geometry. Financial math was included to give students mathematical tools that are applicable in nearly every American adult's life, and introductory statistics was included as an essential mathematical tool for citizenship. The instructor covered the same topics in the winter, with the exception of graph theory.

In addition to requiring students to learn traditional math content, the instructor required all of her students in the QR course with service learning to tutor children in local elementary and middle schools in math. Each student met for 1–2 hours weekly with children at local schools for a total of about 15 service hours logged by the end the term. The more math-phobic students could request to work with kindergarten through fourth grade students, while the students who were more comfortable with math tutored in the fifth through eighth grades. In both classes, the term began with two in-class trainings: one covered the basics of tutoring children, and the other demonstrated the elementary school math curriculum. The local public school district uses the Everyday Mathematics Curriculum,¹ a unique curriculum that was developed at the University of Chicago. This method of teaching mathematics is significantly different from the curriculum most of the students in the course are familiar with from their own elementary school experiences. Everyday Math utilizes games to offer several different methods for learning each math concept. Halfway through the term, a final training on discipline and behavioral issues in the K–8 classroom was offered.

Our university is located near several schools that have high rates of poverty, high percentages of immigrant families (primarily from Asia and East Africa), and large African American and Latino populations. The majority of the QR students were tutoring at these schools, so their assigned reading included articles and book chapters on math education challenges in low-income, diverse communities (Moses and Cobb 2001; Steen 2007; Walker 2007). These readings discussed differences in the level of math literacy between various populations and put forth several possible reasons for the discrepancies. Students in the QR course were required to turn in a weekly journal, which would involve answering questions related both to the readings and to their personal experiences. They also responded to questions in their journals that were focused on their tutoring experiences. For example:

Read the article "Why aren't minorities taking more advanced math?" For your journal assignment, think about the reasons why minorities don't advance in math as often as non-minorities. Do you think the issues faced by minorities are issues for other groups as well? If so, discuss why. If not, why not? Do you have personal experience with any of the phenomena discussed in the article from tutoring or your own life? How have schools you've attended or the schools you are tutoring in perpetuated or avoided the problematic issues the author of this article cites?

For your journal this week, respond to the following questions. (1) Has tutoring helped you understand any mathematical concepts better? If so, explain. (2)

¹ <http://everydaymath.uchicago.edu/> (accessed June 4, 2011)

Have skills you've gained from tutoring been useful to you in other aspects of your life, or do you expect that they will be? Why or why not?

In an effort to share experiences and to think more deeply about math literacy in different populations, the class had three 20-minute class discussions each quarter related to the journal responses. These discussions, as well as the readings and journal responses, provided a basis for students to write a final essay in the class. Students were asked to write five pages responding to the following questions. (1) Is math literacy important in our society? (2) Is everyone capable of achieving some level of math literacy? To support their conclusion, students were required to reflect on their own experience, both as math students and as math tutors, and to include literature references and statistics.

Table 1
Components of the QR with Service Learning Course

Service Learning Component	Corresponding Course Design Component
Academic House	Mathematical instruction includes voting theory, statistics, financial math, Fibonacci numbers and the golden ratio.
Student Voice	Students selected the grade level of their tutoring site. Students with prior tutoring experience above 8 th grade could elect to tutor at a previous community partner site (i.e., high school, community colleges).
Community Partnerships	Students worked with local schools and organizations that have a history of community partnership with our institution.
Community 'Felt Need'	Partner schools had a demonstrated need for improved math and science literacy amongst their students.
Guided Reflection	Students were required to write a math autobiography, weekly journals about tutoring and personal experiences, and a final essay. They also participated in class discussions about their service learning experiences.
Meaningful Evaluation	Community partners submitted evaluations of student-tutors through an online system at the end of the service learning experience. Student-generated reflection was evaluated by the instructor. Students received letter grades for the course. Twenty-five percent of students' grades were based on participation in service and reflection.

The inclusion of the student essays along with other writing assignments fulfilled the guided reflection requirement of service learning. In Table 1, we illustrate how the other components of service learning are addressed in this course.

Analysis

To evaluate the impact of the course as a whole and the service learning component in particular, the instructor relied on several tools to collect qualitative data: a math autobiography assignment at the beginning of the course, journal entries, a focus group interview conducted at the end of the term, an essay on math literacy, and student evaluations of the course.

In the math autobiographies, the majority of students indicated that they had low confidence in their math abilities, that they did not like math, or they were afraid of math. In many cases, all three of these elements were present. The following excerpts from the autobiographies illustrate the students' negative feelings towards math.

“This class was the one I was dreading more than any other. I’ve spent all summer convinced that this was where I would fail out of college.”

“I currently see my weakness in math as a real roadblock in my life both academically and personally. I tend to turn my back on activities and classes that involve mathematical thought. I rely on the people around me to help if there is a quantitative problem to solve; this is something I find extremely embarrassing.”

“As I progressed further and further along in my education, I became increasingly disinterested in math, primarily because I had established for myself earlier on that I was simply not capable of being any good at it.”

“I would enter (math) class with sweaty palms and a racing heart.”

“My disdain for math has remained fairly consistent since high school. I purposefully went to a college that did not have any type of math requirement (which backfired when I transferred to Seattle University).”

“Math has been, and probably always will be, my sworn enemy. Just thinking about the subject makes my skin crawl a bit. My mathematical history is a series of disasters and disappointments.”

“As the years went on and my incompetence became more and more clear, math became almost overwhelmingly anxiety provoking.”

This last quotation is from a student who demonstrated extreme math phobia at the beginning of the course. She had attempted to take our standard QR class twice before and had dropped the course both times. When she came to the instructor's office at the beginning of fall quarter, she turned white as she learned that she would be required to tutor children in math, even though she was assured that she could be placed in a low-level class. Halfway through the term, she wrote the following entry in her journal.

“If I am being completely honest, I was pretty skeptical about the service learning part of this class. My first reaction was, how could I possibly tutor

anyone in math?! I'll probably need a tutor but I could never BE a tutor. Even though it's kids and it's counting and addition, etc., I don't speak math. I can't explain numbers to anyone. I was pretty nervous, but I figured if I stayed positive and pretended to be confident, I can do it... So far I have really enjoyed working with the kids. The anxiety of screwing up or not being able to help has gone way down. I've found that I can usually (though sometimes it's harder than others) answer questions, and it's not the end of the world if I can't. I am excited to see the kids grow and progress in the short time I will be working with them."

This student ended up getting among the highest scores on math quizzes and tests and earned an A in the fall quarter class. Six months later, she related to the instructor that the course had been transformational, one of the most important courses she had taken at Seattle U. At the beginning of winter quarter, a friend of hers wrote in her autobiography, "Finally my friend... gave me the courage to take Math 107. She had failed math twice before taking this class with Dr. Henrich. She said the class took the fear out of math and provided an opportunity to see math in a different light."

In their final essays, students in the service learning courses demonstrated a strong understanding of issues surrounding math literacy, including its importance in society. They began to see connections between math and other aspects of their lives. They described how tutoring helped them gain this understanding. Many students also indicated how the service learning course helped them grow into more math-literate adults.

"The application of math in everyday life has become quite apparent to me in the last three months while taking Math 107, reading *Excursions in Mathematics* and tutoring 4th grade math... The class I tutored allowed me to revert back to my elementary math skills and apply them to problems that affect my daily routine. I realized that the math I learned in grade school has developed and grown."

"By improving reasoning abilities and their relationship to drawing effective, evidence-based conclusions, American pupils would be better equipped in all their courses. The benefits would not only be seen in mathematics classes, but also in other subjects like history, English and social studies where synthesizing information is important."

"As a tutor, I have noticed how much more engaged and willing students are to learn math if they see it as useful outside of the classroom."

"Math is fun at (my school), where the teachers play games and encourage all students to do well in the subject... Students should want to rush to math class after recess and be excited to play math games and learn about multiplication. It is at this school where you learn anyone can learn math. Any age, nationality, race, income level—none of that matters if you have the right attitude and teachers to get you there."

While many of their final essays discuss the students' service learning experiences, the benefit to the student of participating in service learning is not specifically addressed. In the focus group interviews, however, students were asked to think about what they've gained from the service learning portion of the class. One student had the following comment.

"I think with the tutoring, because you had to bring a positive attitude to the kids, it kind of changed my own attitude towards math cause I never had a positive attitude towards math and then seeing how it affected the kids made me feel less like – I don't know – I have less anxiety about math."

When asked by the interviewer to expand on what caused them to change their attitudes about math, students had this response.

Student 1: "I think it's just because I saw that a negative attitude towards math doesn't get anyone anywhere. Like when I was there and I was positive about math, even though I'm just not a math person – I don't really enjoy it – but seeing that a positive attitude changed the kids, like they would actually do their work, they would try to solve things on their own and it made me realize that if I just have a positive attitude towards doing math homework, it wouldn't be such a bore – I wouldn't be like 'oh great, I have to do math now'."

Student 2: "I think that's weird, but I notice that in myself too, and it's odd that some people here did as well, but I can't hit the nail on the head why it changed my attitude. You know, I didn't hate math before – it wasn't pleasant, but something about approaching it so excited and so positive definitely – with the kids – definitely helped me approach my problems in school with math, as well as other problems, with more of a positive attitude, and I felt better about it – I enjoyed it more. I don't know what it was, but yeah, same thing."

Student 3: "I completely agree with what they both said. A positive attitude when you're working with children, it totally transforms the classroom and you actually sort of want – like you don't hate your homework as much, but you approach it in a more positive light. But I definitely enjoy this class and math more after working with children."

It is interesting to note that half of the students (who were randomly selected to take part in the focus group interviews) said that they planned to continue tutoring in their classes for the rest of the year, though volunteering no longer satisfied any course requirement. In fact, the instructor followed up with several students after the quarter's end and verified that many of them did continue tutoring.

Responses to interview questions and written assignments showed that students felt the service learning component of the class was beneficial. Course evaluations were similarly positive. Out of fourteen comments specifically addressing the service learning component, eleven comments were positive.

Negative comments indicated that service learning had not been helpful and suggested that the service learning portion should be optional.

Conclusions

How can we combat math anxiety in college students? In this paper we give one possible solution: to offer this population of students a quantitative reasoning course with a service learning component. Modeled partially on traditional quantitative reasoning pedagogy, our experimental course involved teaching students financial math and statistics, among other topics. The inclusion of a service learning component that required students to tutor children in math was a departure in our course from the more traditional courses.

Core to any service learning experience is an element of reflection. Our students were asked to consider their relationship with mathematics as children, as college students, and as tutors. Students discovered that the act of manufacturing enthusiasm about math as a tool for tutoring kids had the effect of making them more enthusiastic about math in their own courses. Students also discovered that, while they may not be masters of high-level math, they were masters of math on some level. This discovery instilled in them more confidence in their own mathematical abilities and reduced their anxiety.

These initial results regarding the inclusion of service learning into a quantitative reasoning course are encouraging, particularly for populations of math-phobic students. Qualitative evidence suggests that the QR course with service learning at Seattle University has a more profound impact on reducing math anxiety than the version of the course without service learning. We hope to continue offering this course and collect quantitative data regarding its impact on students' math attitudes. We also encourage others to experiment with variations on the idea presented and thus broaden the study of the effectiveness of service learning in quantitative reasoning courses. It is our belief that service learning has the potential to have a positive impact on the levels of math anxiety on a much larger scale.

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