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Attitudes and Experiences in Liberal Arts Mathematics

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Abstract

For many university students, the last formal experience in a mathematics classroom is a single semester "general education" mathematics class. Traditionally, students in this type of class often hold negative attitudes towards mathematics. Here I study a sample of students from this population (49 students at a large, urban, comprehensive public university enrolled in a "math for liberal arts majors" course) to research whether a positive experience in a freshman-level general education mathematics course correlates with a positive change in the students' attitude towards mathematics in general. I also explore which specific aspects of such a course contribute most to a positive student experience.

The survey results show that while a positive experience in a freshman-level general education mathematics course correlates with positive responses in a student's attitude about several key variable components of attitude (including motivation to do mathematics, perceived usefulness of mathematics, and confidence while doing mathematics), it does not correlate with positive change. The course aspects that most correlate with a positive experience include the teacher/professor, difficulty level of the course, and workload.

Keywords: *liberal arts mathematics; affect; motivation; general education; achievement; course aspects.*

1. Introduction

College students majoring in STEM (science, technology, engineering, and mathematics) fields study a relatively well-defined mathematics curriculum, which usually includes calculus-based skills that they will use regularly in their careers. Recently, there has been tremendous attention and funding directed toward students in these majors, in particular those who are enrolled in "gateway" courses such as first-semester calculus. But what of the rest of the students, those who have chosen a major outside of STEM? These students greatly outnumber their STEM peers among all college students [6]. Among these students, what of those who are required to take a single semester-long mathematics course for the sole purpose of fulfilling their general education requirements? This population of students comprises a large proportion of the student body at colleges and universities.

Many colleges and universities have specific courses that are designed to address the needs of these students. Usually, this type of course is a single-semester (or quarter) course specifically intended for "liberal arts" majors to fulfill a general education (GE) requirement. For many of these students, this is the last formal exposure that they will have to mathematics. As educators, this is one of the last settings that we have to expose students to the beauty of mathematics, its relevance to daily life regardless of career choice, and the joy that can be found in problem solving. The impressions and perceptions formed by students in such a terminal course in a bachelor's degree program may influence their attitude towards mathematics for the rest of their lives, and in turn, the lives of their children.

In this paper, I study the effect that such a course has on students. I ask: Does a positive experience in the course correlate with a positive change in the students' attitudes towards mathematics? What aspects of such a course can influence such a change? Affecting such a change in attitude is particularly difficult. Clearly students majoring in a non-STEM discipline who need to fulfill their mathematics GE requirements are the *raison d'être* for such a course. But it is quite common that the typical student in such a context had a bad experience with math at some point in the past, be it with a math teacher or a particularly difficult concept, or just has a feeling of having "fallen off the wagon" and being unable to ever get back on.

This work is different from others because of its target population and goals. There have been many studies on the effect of mathematics classes on students' attitudes about mathematics. However, these have usually been in the setting of more traditional classes, such as algebra or calculus. Studies that have specifically focused on mathematics for general education courses are often recommendations for course design or curriculum. This study combines these ideas by measuring the effect that a course can have on students' attitudes toward mathematics in the context of a course which has already been specifically designed to fulfill GE requirements for mathematics.

2. Relevant Literature

The effect of attitudes about mathematics on a student's performance has been studied extensively since the early 1970s. The seminal 1976 publication [12] by Elizabeth Fennema and Julia Sherman introduced the first questionnaire-style tool designed to measure attitudes towards the learning of mathematics. This survey tool is comprised of 47 Likert-style questions about personal confidence in mathematics, usefulness of mathematics, mathematics perceived as a male domain, and the students' perception of the teacher's attitude. This survey tool is still commonly used in mathematics classrooms today and has been subject to numerous reviews, critiques, and revisions [8, 25]. Another important tool developed in the 1970s was Richardson and Suinn's 1972 Mathematics Anxiety Rating Scale [23]. A revised abbreviated version, usually referred to as A-MARS, is still widely used today [2].

The widespread use of tools such as Fennema-Sherman and A-MARS greatly influenced research into *affective* variables in mathematics and how they relate to achievement in college students [11]. The term "*affect*" in mathematics, while not strictly well-defined, generally relates to a student's beliefs and attitudes towards studying mathematics [1, 9]. In fact, so many articles, books, and online resources have been published on this topic that top journals have conducted large-scale reviews of these publications [19].

Although there is no single set of key variables to be measured that will uniquely determine a student's attitude towards mathematics, several are prevalent in the research. First, the student's reported confidence while doing mathematics often has a strong impact on their attitude towards mathematics [13]. Within the scope of confidence while doing mathematics is the student's perception of "being a math person". In the U.S. in particular, it is a commonly held belief that there are those who can "do math" because of some innate "math-brain" ability that they were born with, and those who simply cannot "do math" because they are not a "math person." Sadly, the vast majority of college students, especially those in non-STEM majors, self-identify in this second category [10]. Although it can be shown that this argument is nonsense and that all students can learn mathematics, the perception persists in the US culture [7]. Until the student can be convinced that anyone can learn mathematics, he/she has already crippled his/her personal confidence by identifying with the "have-not" group [10].

A second key variable related to students' attitude towards mathematics is their perception of its usefulness. This key variable, as well as the previously mentioned key variable of mathematics confidence, have consistently been shown to impact attitude towards mathematics since the earliest administrations of Fennema-Sherman's questionnaire [19, 13]. To address this issue, mathematics teachers often intentionally include "real-life" examples, such as mathematical modeling or applications with the intent of showing the student that mathematics is useful and relevant to them now, and for their future [21]. This emphasis is present long before the student is in college; in California, it is an important part of the new Common Core state standards for K-12 students [20]. In part because of the relationship between being able to solve this type of problem and the students' perception of the usefulness of mathematics, this type of problem has been incorporated heavily into the curriculum for liberal arts mathematics at the college level.

The last key variable intended to measure attitude toward mathematics that was identified to be measured in this study is the students' motivation to do mathematics. While this has some overlap with the previous category, it is important to address motivation individually because a lack of motivation will often result in a lack of confidence and apathy towards the subject [24]. Motivation to do mathematics is formed over many years and countless mathematical experiences, and students may have had limited opportunities for positive experiences in mathematics. Students may consciously choose a productive and positive attitude towards mathematics—but only when they are exposed to assignments and tasks that resonate with their personal goals [17]. In his 2012 Outstanding Professor lecture at CSU Fullerton, Martin Bonsangue speaks about "math stories"—particularly those belonging to students who have performed poorly in a mathematics course or have chosen to avoid mathematics altogether [5]. These students often reference a single bad experience with mathematics (be it a particular topic, subject, teacher, etc.) as the reason that they felt they "could not do math". A lack of motivation in mathematics is one of the first concrete manifestations of a deeply seated fear of doing mathematics—why spend time and energy on something that is a lost cause?

Seeking out methods to improve college students' attitudes towards mathematics, as well as defining key variables for attitude toward mathematics, is still a prevalent research topic today. A large part of the impetus for this research is the assertion that a student's positive attitude towards mathematics will result in higher levels of achievement in mathematics. Although the strength of correlations between students' attitudes about mathematics and their actual mathematical performances has varied over the years, many studies have shown that a college student's positive attitude towards mathematics correlates to higher achievement in mathematics courses [14, 18]. Recent examples of such studies include Kim and Hodges's 2013 study of improving attitudes toward mathematics for students in a college algebra course [16]; Hemmings and Kay's 2010 study of secondary school students in a traditional mathematics curriculum [15]; and Pyzdrowski's 2013 study about student indicators for success in entry-level college calculus [22].

Although these studies provide a strong basis for the research presented in this study, most were conducted in the context of a "traditional" curricular setting such as algebra, pre-calculus, or first-semester calculus; there have been few conducted specifically in the setting of a university-level "math for liberal arts" course. It is however important to study this latter context specifically because students taking such courses differ significantly from their mainstream counterparts. First, the reason to take and pass the course is different. Students in an algebra, pre-calculus, or calculus class often continue in the calculus pipeline, which means that this class is likely to not be a terminal mathematical experience. For students in a liberal arts mathematics class, it is likely to be the last formal instruction that they will receive in mathematics [26]. Second, students enrolled in the more traditional classes have usually chosen a major that requires them to take this type of class for the express purpose that they will need these mathematical skills to succeed in advanced classes in the major. On the other hand, it is not uncommon that students in a liberal arts mathematics class have specifically chosen their major or desired career so that it will involve a minimal amount of mathematics [4]. Finally, the curriculum itself is different. Rather than building a comprehensive skill set to serve as a foundation for more advanced classes, liberal arts mathematics courses tend to focus more on a variety of topics with the intent to expose students to many different kinds of mathematical thinking and applications [3]. Given such differences in purpose, population, and curriculum, it is at least plausible that students in a liberal arts mathematics class may answer questions about the key variables significantly differently from their more traditional counterparts.

3. Research Questions

Based on the literature review in the previous section, this study has been designed to measure the attitudes of students who are currently enrolled a liberal-arts mathematics course. Changing or modifying the curriculum, teaching methods, or other aspects of the course was strictly outside of the scope of this study. Rather, I investigated an existing course and the potential impact that taking the course had on students' attitudes toward mathematics.

More specifically, in this study, I aimed to address the following research questions:

1. Does a positive experience in a freshman-level general education mathematics course correlate with a positive change in the students' attitude towards math in general?
2. What course aspects contribute most to a positive experience?

I compared positive experiences with students' reported overall opinions on the course. Attitude towards mathematics was captured by 1) perceived usefulness of mathematics; 2) perceived personal ability in mathematics; and 3) motivation to learn mathematics. Also included were questionnaire items with a free response component regarding specific course aspects. Among these course aspects were items such as *classroom environment*, *difficultly of the class*, *time spent working in groups*, *teacher/professor*, *exam preparation.* Readers can refer to Appendix A for the specific list.

4. Methodology

I chose to sample students at California State University Fullerton (a large public university in the United States) taking Math 110, a first-year liberal arts mathematics course. While many first-year students at CSU Fullerton take other mathematics classes for GE credit, including algebra, pre-calculus, calculus, and statistics, the class from which the sample was taken is the only mathematics class at this university specifically intended for students who need to fulfill a GE requirement for mathematics, and will take no other mathematics classes as part of their major and/or minor requirements. The course has a standard book and core curriculum across sections, both determined by a course coordinator. However, instructors do have the freedom to choose 1-2 additional topics, which I consider in the questionnaire.

I chose to sample students at this university because this group of students was accessible to me as a lecturer at the university. Because of the large size of the student body, there were many individuals available and willing to participate in the study. In addition, although the sample came from students attending classes with several different teachers, the standardization of the course material across sections helped to control other factors that may have affected students' experiences.

Because of time constraints, it was necessary to ensure that the study was considered IRB-exempt. Several aspects of the survey design, including anonymity, self-reported grades, and the online distribution, were chosen in order to preserve this status. Questions about demographics, including gender, class standing, ethnicity, and age, were removed from the study design in order to preserve IRB-exempt status.

Four out of five instructors for the course chose to participate, with seven out of ten total class sections between them. There were approximately 300 students enrolled in all sections the course during this semester. I visited each class to briefly explain the study and clearly indicated that the study was anonymous and voluntary. Students were then asked to provide their school email addresses so that we could send a link to the online survey. For those students that provided their email addresses, an initial email was sent within twelve hours including the survey link administered through Qualtrics, an online survey platform. Two reminder emails with the survey link were sent over the next ten days to these students. One hundred fifty-three students provided a valid email address and received these three emails. The students had about three weeks to respond. I obtained 49 responses, resulting in a 32% response rate. No incentive (lottery, extra credit, etc.) was offered to students for participation. A standard online cover letter/consent form was given to the student before he/she began the questionnaire, which took less than ten minutes for most students to complete.

The questionnaire has four sections. The first section asks the student to identify their most and least favorite core topics from the course, as well as their favorite additional topic. There are questions about students' perceptions of the usefulness of the topic, their confidence in it, and their motivation to study it. The second section asks about the difference in students' attitudes towards mathematics currently versus their attitudes in high school. Attitude is measured via questions about motivation, confidence, and perceptions of usefulness. This section ends with a question about the "overall" experience in the course. The third section asks the students to identify aspects of their course that have an impact on their learning, and to indicate the strength and direction of that impact. Students could write in course aspects, and there is a short-answer question asking the student to identify the most important aspect of a math course for them to succeed. Finally, the fourth section is comprised of questions about self-reported grades in the course and GPA, as well as performance in past mathematics courses. The questionnaire, question numbers, and coding for the key variables may be found in Appendix A.

The key variables of the study are defined as follows: motivation to do mathematics, perceived usefulness of mathematics, confidence when doing mathematics, overall experience in the course, high school versus current opinions and attitudes, course aspects, and preparation for the course.

5. Results

In order to describe the sample without access to responses to standard demographics questions, we first consider the students' preparation for the course. Student-reported grades in previous mathematics courses serve as indicators of their preparation for this course. The most common recent mathematics classes that students had successfully completed with a grade of "C" or better prior to this course were algebra (53.1%) and pre-calculus (24.5%). Other courses reported included geometry, statistics, trigonometry, and assorted high school "math studies" courses. The median of the grades reported for these classes was a "B" grade.

As most of the students involved were second-semester students, they could also report on their college GPA as of the previous semester. The median GPA reported was in the 2.00-2.49 category. Students' reported performance in Math 110 so far was measured by asking about their grade on their most recent exam, as well as the semester grade they realistically expect to earn in the class. The median exam score reported was "C+". The median grade expected for the semester was "B/B-".

The questions addressing the key variables of confidence, motivation, and perceived usefulness of math were all Likert-scale items, with 1 = "strongly disagree"; 2 = "disagree"; 3 = "agree"; and 4 = "strongly agree." The group of questions measuring confidence had a Cronbach's alpha of .75; measuring motivation, $\alpha = .77$; and measuring perceived usefulness, $\alpha = .82$. The negatively worded questions (6-8) resulted in a marked decrease in Cronnbach's alpha for question sets measuring each of these key variables even after recoding; therefore, these questions are not included in the key variables. Responses to these questions are omitted in the following analysis.

Students' responses to the questions regarding motivation show that, on average, students agree that they feel motivated to study mathematics when studying a favorite topic; see Figure 1 below. Both of the questions about this had an average response of 3.0, with a standard deviation of about 0.7. Students also indicate that their current level of motivation to study mathematics is higher currently (mean response of 2.59, with a standard deviation of .79) than that of when they were in high school (mean response of 2.39, with a standard deviation of .73). However, a paired-samples t-test shows that this difference is not significant at the $\alpha = .05$ level.

Students felt most motivated to study mathematics when they were being asked about a topic that they identified as one they enjoy. A paired samples t-test shows that there is a significant difference at the $\alpha = .05$ level between students' responses to motivation while studying a favorite topic versus their current overall motivation to study mathematics, with a p-value of less than .001. When asked about motivation while studying a favorite core topic, more than 83% of students said "agree" or "strongly agree" to feeling motivated to learn math while studying this topic. However, when asked the same question for math in general, almost 50% of the students responded "disagree" or "strongly disagree."

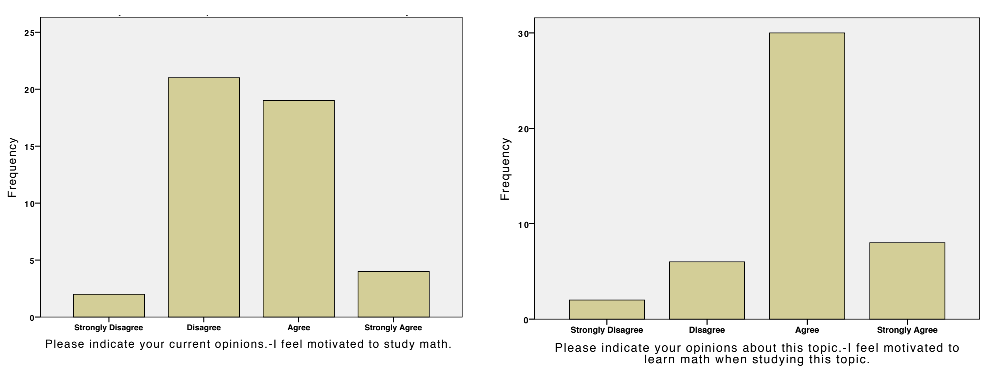

Figure 1: Motivation for favorite core topic vs. current general motivation.

A similar result was found for the questions measuring confidence when solving mathematics problems. There is a significant difference at the $\alpha = .05$ level between students' confidence while studying a favorite core topic versus their current overall confidence to study mathematics, with a p-value of less than .001. Regarding perceived usefulness of the topic, there was no significant difference between students' opinions while studying a favorite topic versus their opinions in general. The most favored "core" topic was logic, with 39.6% of students choosing it over finance, counting, probability, and statistics. Conversely, 51% of students identified finance as their least favorite core topic.

The average response for questions about current confidence in mathematics when working on a favorite topic was 3.27 for core topics and 3.10 for additional topics. However, the average responses for questions about current confidence in mathematics in general were much lower, at 2.78 and 2.46. These averages were similar to those for confidence in mathematics during high school, with average responses of 2.49 and 2.35 for the two questions pertaining to this topic. The questions asking if the student identified as a "math person", now or in high school, were much lower than their responses to general questions about confidence. The average response to this question was 1.86 for high school and current opinions. This means that on average, a student who responded by saying they agreed or strongly agreed with feeling confident while solving problems from a favorite topic, may have agreed or disagreed with feeling confident about solving mathematics problems in general, but disagreed or strongly disagreed with identifying themselves as a "math person," see Figure 2 for a summary of responses on confidence.

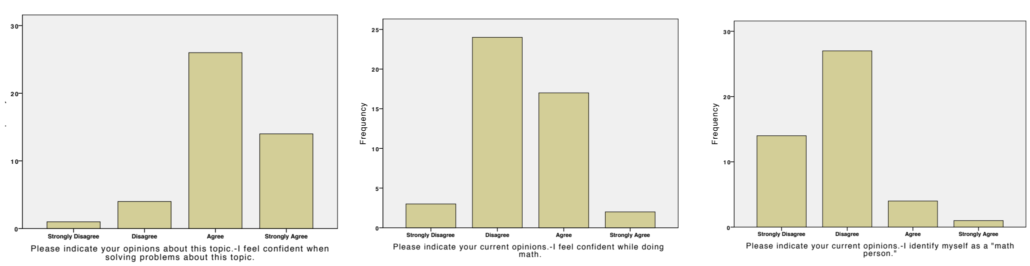

Figure 2: Responses to questions about current confidence levels.

In fact, the paired-samples t-test shows that for *all* questions that asked about current overall confidence levels, be it for a favorite topic or overall confidence, there was a significant difference at the $\alpha = .05$ level between the responses for *each* of these questions and "I identify myself as a math person".

When asked about the perceived usefulness of mathematics, students responded fairly consistently for all of the questions relating to this variable. When asked about the importance of math in general, the mean and standard deviation were exactly the same for opinions in high school and current opinions (mean of 2.73 and a standard deviation of .81). The median and mode response to all four questions about perceived usefulness of math was a 3, which shows that most students "agree" with questions about the perception that math is important to their futures.

The key variables of confidence, motivation, and perceived usefulness all had paired questionnaire items where the respondent was asked about his/her opinions in high school, compared to his/her current opinions. The researcher conducted paired samples t-tests on each of these pairs at the $\alpha = .05$ significance level. In all five cases, no significant difference was found between the average responses about high school opinion versus current opinion.

The questionnaire also asked about the students' overall experience in Math 110, see Figure 3 below. None of the respondents reported a "very negative" experience in Math 110. 17% responded "somewhat negative"; 47% "somewhat positive"; and 36% "very positive."

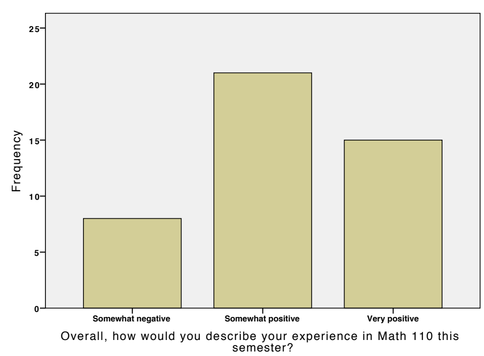

Figure 3: Students' overall experience in Math 110.

There are direct correlations significant at either the .01 or .05 significance level between responses to all of the questions about the key variables of motivation, confidence, and perceived usefulness, with overall Math 110 semester experience; we record these in Table 1 below. This means that students who responded positively to any of the questions about current levels of motivation, confidence, or perceived usefulness, were more likely to respond positively when asked about their overall Math 110 semester experience. The strongest correlations, all with $p < .001$, were “I (currently) feel motivated to study math”; “I think it will be useful for me to know about this (core) topic in the future”; and “I feel confident while doing math.” For all of these questions, $46 \leq N \leq 49$.

Key Variable Correlations to Overall Experience		
Overall, how would you describe your experience in Math 110 this semester?		
I feel motivated to learn math when studying this (core) topic.	Pearson Correlation	.381*
	Sig. (1-tailed)	.004*
I felt motivated to learn math while studying this (additional) topic.	Pearson Correlation	.407*
	Sig. (1-tailed)	.002*
I feel motivated to study math.	Pearson Correlation	.474**
	Sig. (1-tailed)	.000**
I think that it will be useful for me to know about this (core) topic in the future.	Pearson Correlation	.474**
	Sig. (1-tailed)	.000**
I think that it will be useful for me to know about this (additional) topic in the future.	Pearson Correlation	.324*
	Sig. (1-tailed)	.014*
I think that math will be important for my future.	Pearson Correlation	.267*
	Sig. (1-tailed)	.035*
I feel confident when solving problems about this (core) topic.	Pearson Correlation	.333*
	Sig. (1-tailed)	.012*
I feel confident when solving problems about this (additional) topic.	Pearson Correlation	.329*
	Sig. (1-tailed)	.013*
I feel that I can succeed in math.	Pearson Correlation	.327*
	Sig. (1-tailed)	.012*
I feel confident while doing math.	Pearson Correlation	.502**
	Sig. (1-tailed)	.000**
I identify myself as a ”math person.”	Pearson Correlation	.457**
	Sig. (1-tailed)	.001**

*Significant at the .05 level.
** Significant at the .01 level.

Table 1: Key attitude variable correlations to overall experience.

We next attempted to predict overall course experience using the eleven independent variables in Table 1. We used a stepwise regression procedure, replacing missing data with the mean. The results from this regression are presented in Table 2 below.

Independent Variable	**Beta**	**t**	**sig. t**
I feel confident while doing math.	.432	3.752	$< .001$
I think that it will be useful for me to know about this (core) topic in the future.	.405	3.514	.001
$R = .637$, $R^2 = .406$, $F = 15.724$, $sig.F < .001$			$N = 49$

Table 2: Prediction of course experience with attitude variables.

Of the eleven independent variables, two of them entered the regression equation. The R^2 was .406. Both of the variables were statistically significant at the .05 level. Inspection of the betas revealed that the most powerful predictor for course experience was the students' confidence level while doing mathematics.

Students were also asked to identify how different aspects of their course impacted their learning experience; we present the data for two of the aspects in visual form in Figure 4 below. Questions were a 5-point Likert scale as before, but with the additional category of 3 = "not applicable to my experience." More than 85% of students responded that the following course aspects had a "positive" or "very positive" impact on their course experience: *teacher/professor*, *fairness of grading*, *classroom environment*, *time spent on lecture*, *exam preparation*, *curriculum*, and *workload*. Students responded most negatively to the course aspects of *difficulty of class* (16% very or somewhat negative); *time spent working in groups* (22% very or somewhat negative); *pace of the class* (18% very or somewhat negative); and *online homework* (30% responded very or somewhat negative). The course

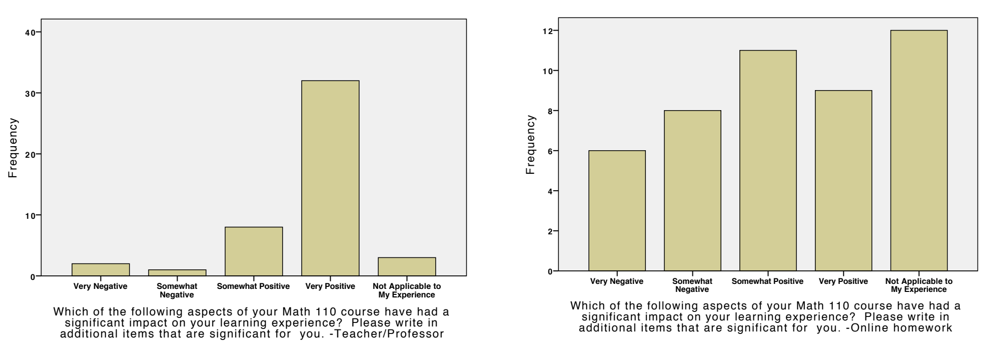

Figure 4: Course aspects and their impact on students.

aspect that had the most positive impact on students, with a mean of 4.5 and median/mode of 5.0, was *Teacher/Professor*.

The course aspects that had the strongest direct correlations to an overall positive experience in the course (both with $p < .001$) were *teacher/professor* with a Pearson's r of 0.59, *difficulty* ($r = .55$), and *workload* ($r = .56$). This means that students who answered more positively about these course aspects were more likely to indicate that they had an overall positive experience in the course. No course aspects were identified as having a significant negative correlation with overall student experience.

Students were also asked to identify any additional course aspects that had a significant impact on them in this section. Students identified *studying*, *contact with professor*, *quizzes*, and *attendance* as aspects of a course that had a somewhat or very positive impact on them. No negative aspects were identified in this free-response section.

At the end of this section, students were asked to identify what is most important for them to have a positive experience in a math class, and to explain why. Forty-five of the 49 survey respondents took the time to answer this question, even though it required them to write. Of these, 28 students (62%) identified something relating to the professor or teacher as being the single most important thing for them to have a positive experience in math. Responses also emphasized the importance of feeling comfortable asking questions, fairness in grading, interesting and engaging curriculum, clear explanations, and test preparation.

6. Discussion

The implications of the data in the previous section are discussed in this section. First, students' grades and preparation for the course are interpreted. Then, I discuss how the data address the two research questions presented earlier in the paper. Finally, I draw a conclusion about each research question based on the observed data.

Considering students' preparation for the course, most students indicated that the last mathematics class they successfully completed was an algebra or pre-calculus class, with a median reported grade of "B". The majority of students in spring-semester sections of the course are historically freshmen—specifically, freshmen who have previously failed the course or been engaged in a remedial course of study. During informal conversations, several of the professors from this study indicated that there is a huge difference in students that take this course in the fall and those in the spring. Specifically, they indicated that spring-semester students in this class are notoriously negative regarding the key variables of motivation to do mathematics, perceived usefulness of mathematics, and confidence while doing mathematics. This is important because this sample is taken exclusively from students taking the class during the spring semester, which may have an impact on how they answered the questions.

Because grades were self-reported, the responses to these questions were treated more as information about preparation for the course and the students' perception of their performance, rather than "hard data" such as end-of-semester grades obtained directly from the teacher or department. Responses to the key variable of grades/GPA shows that while, curriculum-wise, students had generally had adequate preparation for the course from high school material and reported passing GPAs, they had still likely failed the course the previous semester or been previously engaged in a remedial course of study.

The first research question is addressed by the findings about the key variables of motivation, confidence, and perceived usefulness, as well as their overall experience. First, the questions to each of these three aspects of attitude toward mathematics showed reasonably high Cronbach's alpha scores after the negatively worded questions had been taken out. This indicates that responses to the questions analyzed were consistent with one another. It is likely that students did not realize this middle section was worded differently and thus answered "backwards." Therefore, we can conclude that the data are consistent. The medium-to-strong direct correlations between positive responses in these categories and the students' overall experience suggest that intentionally addressing these three aspects of attitude toward mathematics in this course results in a better class experience for the student. The multiple regression suggests that a student's overall course experience is positively affected by their overall current confidence level while solving mathematics problems, as well as their perception of the usefulness of a favorite core topic.

However, the first research question implied that a positive experience in the course could potentially be correlated with a positive change in attitude. In every single one of the questions about attitude towards mathematics, there was no significant difference between a student's current attitudes and the attitude that they reported they held in high school. This was true for all three dimensions of perceived usefulness, motivation, and confidence. Therefore, we can conclude that while a positive experience in a freshman-level general education mathematics course correlates with positive responses in the student's attitude towards mathematics in general, it does not correlate with positive change.

The second research question is addressed by the questions about course aspects, including the free-response question. The single most important course aspect identified by students as having a positive or very positive effect on their course experience was *the teacher or professor.* This was true in both the Likert-style section about different course aspects, and in analyzing the free responses written by student. Other factors that student identify as especially important for success were *course difficulty* and *workload*. The strong direct correlations between these course aspects and students' overall experience show that focusing on improving these aspects of the course will have the most pronounced positive effect on students. Although students reported that *time working in groups* and *online homework* affected them negatively, there was no significant correlation observed between these course aspects and reported overall course experience. Therefore, we conclude that while many course aspects were reported as having either a positive or negative effect on the student, the aspects of *professor/teacher*, *course difficulty*, and *workload* yielded the most significant correlations with overall experience.

Although it was not intentionally addressed in the research question, we did find that students' response to questions about confidence in solving mathematics problems in general is different from their response to "I identify myself as a math person". This shows that on average, even if a student feels confident solving mathematics problems and feels that they are able to "do math", they still do not identify themselves as a "math person"! This corroborates the argument found in the literature that the perception that there are people who have a "math brain" and other people who simply do not, is persistent in this sample. Indeed, even if a student specifically feels that they have the ability to "do math", they will not self-identify as a "math person." This dichotomous perception is one of the most deep-seated beliefs held by students about their so-called mathematical ability.'

7. Recommendations for Future Research

Although these results are promising, we have several recommendations for repeating the study that would strengthen the results considerably.

A significant limitation of the present study is that it came from a one-time sample from a single semester, from a relatively small population. For more conclusive results, a larger sample is necessary. This is a reasonable goal, and can be attained simply through a repetition of the study in the fall, as many more students are enrolled in this course during fall semesters. Indeed, because there is such a large difference in the student population enrolled in this course when comparing the spring semester to the fall, results from a spring pilot may not be consistent with those obtained through a larger study conducted in the fall.

The low response rate also limited the study, as it resulted in a relatively small sample size. Administering a paper questionnaire during class time, rather than requesting that students fill out an online questionnaire, would obtain a better response rate. Given that this study had the strong support of both the mathematics department chairman and the course coordinator, as well as several of the professors, this would be reasonable to implement as long as the questionnaire was still relatively short. Employing random sampling techniques could also strengthen the sample, but this was not feasible in this case due to privacy restrictions.

Some minor changes should also be made to the questionnaire itself. I recommend rewording questionnaire items 4 through 6 into positive language, as it was evident that some students answered these questions "backwards." In addition, some of the other course aspects identified by way of free response could be included in the given list. Finally, it would be valuable to find out why Math 110 did not seem to change students' high school attitudes. This could be addressed with a free-response item such as "I wish we had studied ________ in this course" or "What would have made this course a more positive experience for you?" In general, however, the questionnaire tool worked quite well—in some sense, these results helped to serve as a validation study as well. However, further investigation regarding consistency and validity of measurement is necessary.

I asked the students about their current opinions versus their high school opinions in a single sitting. It is plausible that they may have answered these questions more similarly than they would have had they been surveyed in high school and again in college. A longitudinal study may address this question. In a larger study, it would also be important to obtain demographics information, as well as data on actual student grades, both in this course and in their previous mathematics classes. This information may be hard to obtain, as it is protected by FERPA (Federal Education Right to Privacy Act). Further investigation about how these additional criteria might affect the study's IRB status is needed as well.

Moreover, additional key variables could be addressed, such as the students' perception of the teacher's engagement. As there is no well-defined set of key variables to measure mathematical attitude, nor a strict definition of attitude toward mathematics itself, much additional research could be done in this area. In particular, researching these issues among students enrolled in a terminal mathematics class could show different results from those obtained from their mainstream counterparts. Changes in the course curriculum or course design would also likely have a profound impact on how students responded to the questionnaire. There is still much that is unknown about these issues, and this student population in particular.

8. A Personal Conclusion

Although none of the students surveyed in this study were my own students, the results of this study reflect what I observe in my own classes. Students in my liberal arts mathematics classes often find one or two topics we study interesting, and show higher levels of engagement when studying these topics as opposed to others. Some students do consistently engage in the material throughout the semester; yet, those same students tell me, "I'm just not a math person". On course evaluations, I often see comments that begin with"Even though I don't like math" followed by a positive comment on one of the course aspects that this study identified as most influential.

My goal in this project was to investigate how experiences in a liberal arts mathematics class may shape future attitudes about abilities. It is important for those of us teaching these courses to understand where our student are coming from and how we can tailor our courses to provide a good mathematical experience, all the while keeping the integrity of the mathematics intact. Many years from now, I hope that when my students remember our course, they can think, "There are lots of interesting and useful things to learn about mathematics, and I am capable of learning about them."

A. Coded and Numbered Questionnaire

Data coding values shown.

1. **Which of the following is your favorite Math 110 "core" topic?** (Circle one)

Logic	Finance	Counting	Probability	Statistics
1	2	3	4	5

Please indicate your opinions about this topic by putting an "x" in the appropriate box	Strongly Disagree	Disagree	Agree	Strongly Agree
2. I feel motivated to learn math when studying this topic.	1	2	3	4
3. I think that it will be useful for me to know about this topic in the future.	1	2	3	4
4. I feel confident when solving problems about this topic.	1	2	3	4

5. **Which of the following is your least favorite Math 110 "core" topic?** (Circle one)

Logic	Finance	Counting	Probability	Statistics
1	2	3	4	5

Please indicate your opinions about this topic by putting an "x" in the appropriate box.	Strongly Disagree	Disagree	Agree	Strongly Agree
6. I do not feel motivated to learn math when studying this topic.	4	3	2	1
7. I do not think that it will be useful for me to know about this topic in the future.	4	3	2	1
8. I do not feel confident when solving problems about this topic.	4	3	2	1

9. Which of the following additional topics discussed in class did you most enjoy? (Circle one or write your own)

Sets	Numeration Systems	Numbers	Geometry	Graph Theory	Other
1	2	3	4	5	6

Please indicate your opinions about this topic by putting an "x" in the appropriate box.	Strongly Disagree	Disagree	Agree	Strongly Agree
10. I feel motivated to learn math when studying this topic.	1	2	3	4
11. I think that it will be useful for me to know about this topic in the future.	1	2	3	4
12. I feel confident when solving problems about this topic.	1	2	3	4

Please think back to when you were in high school, and answer the following questions based on your thoughts and feelings **during that time**. Place an "x" in the appropriate box.

	Strongly Disagree	Disagree	Agree	Strongly Agree
13. I felt motivated to study math.	1	2	3	4
14. I felt that I could succeed in math.	1	2	3	4
15. I thought that math would be important for my future.	1	2	3	4
16. I felt confident while doing math.	1	2	3	4
17. I identified myself as a "math person."	1	2	3	4

Please indicate your **current** opinions. Place an "x" in the appropriate box.

	Strongly Disagree	Disagree	Agree	Strongly Agree
18. I feel motivated to study math.	1	2	3	4
19. I feel that I can succeed in math.	1	2	3	4
20. I think that math will be important for my future.	1	2	3	4
21. I feel confident while doing math.	1	2	3	4
22. I identify myself as a "math person."	1	2	3	4

23. Overall, how would you describe your experience in Math 110 this semester?

Very negative	Somewhat negative	Somewhat positive	Very positive
1	2	3	4

Which of the following aspects of your Math 110 course have a significant impact on your learning experience? Please write in additional items that are significant for you.

1= *Very Negative* 2= *Somewhat Negative* 4=*Somewhat Positive* 5=*Very Positive* 3= *Not Applicable*

24. Teacher/Professor	1	2	3	4	5
25. Fairness of grading	1	2	3	4	5
26. Classroom environment	1	2	3	4	5
27. Difficulty of class	1	2	3	4	5
28. Time spent working in groups	1	2	3	4	5
29. Time spent on lecture	1	2	3	4	5
30. Pace of the class	1	2	3	4	5
31. Exam preparation	1	2	3	4	5
32. Online homework	1	2	3	4	5

33. Topics covered (curriculum)	1	2	3	4	5
34. Workload	1	2	3	4	5
FR1. Other ____________	1	2	3	4	5
FR2. Other ____________	1	2	3	4	5
FR3. Other ____________	1	2	3	4	5

FR 4. What is **most important** for you to have a positive experience in math class? Please briefly explain why.

35. What is the most recent math class that you successfully completed before Math 110 (semester grade of C or better)?

Algebra	Geometry	Pre-Calculus	Calculus	Statistics	Other
1	2	3	4	5	6

36. What grade did you earn in this course? (Circle the best fit.)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
4.0	4.0	3.7	3.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0	0.7	0

37. What was your grade on your most recent Math 110 exam? (Circle the best fit.)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
4.0	4.0	3.7	3.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0	0.7	0

38. What semester grade do you realistically think you will earn in Math 110? (Circle the best fit.)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
4.0	4.0	3.7	3.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0	0.7	0

39. What is your current college GPA? (Circle the best fit.)

Lower than 1.50 1.50-1.99 2.00-2.49 2.50-2.99 3.00-3.49 1 2 3 4 5

3.50-3.99 4.0 or higher N/A 6 7 8

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