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Title: It's Not the Math They Hate

Math Education / Philosophy of Mathematics

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It Is Not the Math They Hate

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Abstract I

A large portion of the college student population often struggle with learning pre-calculus mathematics. There are a multitude of reasons why students struggle with mathematics, one of which is having a general dislike, often expressed as a hatred, of mathematics. When students enroll in a mathematics course with preconditioned judgments, it is quite likely to affect their confidence and success rate in the course. This study will qualitatively investigate the origins of when, where, and why the aversion to mathematics began for students. Students from Intermediate Algebra courses (154) and a Calculus II course (10) voluntarily filled out a five-question open response research survey.

We are what we repeatedly do.
Excellence, then,
is not an act,
but a habit.
-Aristotle

Abstract II

I have taught mathematics to students, a high percentage of who do not particularly like mathematics (non-math majors ages 7 to 70), for over twenty years. My research, quantitative and qualitative, has shown that it is not the mathematical content students hate, but rather the teacher and method of instruction / presentation of material. A few student responses follow:

" I think the single most important factor in learning mathematics is having a teacher who makes the experience positive. Even if you may not be "good" at math, if you have a positive experience you are more prone to not give up: not enjoy it."

"Most of them have made me dislike math even more. My past math teacher were stern, and really harsh graders. No matter how hard I try to like math, no matter how hard I study, Math just makes me freak out because of all my past math classes. I hate to think, that it's High School math, only harder. They always made it seem hard, they never used terms I could understand, and made it seem a lot harder then it probably is."

"Yes, If I didn't like a teacher I usually did not pay attention resulting in the teacher disliking me and me disliking the teacher even more, it was a vicious cycle. Teachers can make you feel very inferior and yourself esteem is lowered and you don't participate in class. Therefore you don't let yourself learn."

"The teachers I have had for math have definitely fueled my dislike for Math. I had the same teacher for Geometry and Pre-Calc in High school. This teacher used Methods that I did not understand. I so disliked this teacher that I would try to do bad on tests or not put in an effort to make him mad."

Mathematics is a creation of the human mind (so can be understood by all humans to particular levels), an inanimate object, an idea. It is illogical to hate something that has done nothing to oneself; it is like having a disdain for a desk.

It is time to start emphasizing the teaching of mathematics in a psychological and philosophical approach. Content knowledge is important but not more so than the intangibles; patience, persistence, and passion to name a few. Math teachers need to expect a lot from their students and deliver more in terms of enhancing students' belief in their abilities to do mathematics.

Mathematics needs a public relations makeover. Perceptions need to be remolded. Hard and difficult are figments of one's psyche. Mathematics can be viewed as an intellectual game (chess), an opportunity to question, explore, have fun, and get excited. Wrong answers are a path to learning and an opportunity to "play the game" again and again.

Students enjoy challenges in many aspects of their lives; mathematics can be viewed as a challenge that can be overcome with effort and commitment. I do not propose everyone will love mathematics, but for those who have an aversion toward it, they need to give math, themselves and a committed teacher another chance to experience the beauty mathematics has to offer. Mathematics can be a confidence builder not breaker.

INTRODUCTION

It has been my experience that the word "mathematics" brings forth feelings of spine-tingling fear from the majority of the masses while giving way to a regrettable respect. Prevailing thoughts imply that mathematics is primeval and practical, needed and necessary; yet, it remains mysteriously aloof and inaccessible to the majority. It seems that a love-hate relationship has engulfed mathematics. It plays the roles of the "redheaded stepchild" and the prodigal son; it creates anxiety and ecstasy.

J. W. A. Young published *The Teaching of Mathematics* in 1906. He put the emphasis of learning mathematics on teacher knowledge and presentation; I would add that an educator may also focus on student effort. Teaching mathematics and learning mathematics are separate entities. In my opinion, the mathematical community has to address this duality. Mathematics is an invention of the human mind; therefore, the way it is perceived, taught, and accepted is also subject to the variances in human responses and emotions.

Young (1906) published his book over 100 years ago, but I believe it could have been written yesterday. It makes me wonder what has been going on in the field of mathematics education when Young's concerns are my concerns. If mathematics is logical and people are capable, it is curious that the mathematical problems of the 1900s are still problems of the 2000s. Perhaps the teachings of mathematics have not accommodated to the processes of learning.

The field of education has a unique feature in that there is no one correct method of instruction for any discipline, including mathematics. The emphasis of mathematics instruction has traveled a long path, from the basis of the three r's (reading, writing and arithmetic) to the

passing of nationally standardized tests (No Child Left Behind legislation of 2002). The point being that methods of mathematical (as well as other disciplines) instruction have seen many changes throughout the years and will possibly see many more in the future.

Mathematics can be viewed as exercise for the mind; it can be a confidence builder, not breaker. For many, learning mathematics may be the most difficult thing they will do throughout their educational life; perhaps if they can do mathematics, the world and its opportunities is their playground.

Before embarking on the study's student responses, I would like to provide some background in some areas of mathematics education. I believe these areas to be important aspects to be considered by students and teachers. I have labeled them changing perspectives, teacher instruction, and self efficacy.

Changing Perspectives

Szydlik (2000) expresses a difference between individuals who do well at mathematics and those who do not. Szydlik says a high number of mathematicians find many mathematical ideas difficult, but they have internal sources of conviction and the ability to eventually make sense of the ideas. However, students with external sources of conviction will not make sense of mathematics unless their sources of conviction are shifted. Another perspective could involve the mastery concept of aptitude as time to learn in contrast to a traditional concept of aptitude as how much is learned. For some it might come down to a personal challenge, a perspective of not letting the mathematics defeat them. If the student commits to learning the processes needed to solve certain types of problems and then can recognize different types of problems, the mathematics involved is often reduced to only arithmetic. Driscoll (2000) refers to this process as schema learning. A case in point is finding the equation of a line. One needs to know the necessity of having a point and a slope and knowing a form of an equation for a line. Knowing these things, the formation of the equation is reduced to adding, subtracting, multiplying, and/or

dividing numbers.

Not everyone learns spatially (some prefer to think of three dimensions in terms of matrices), so the mathematics teaching community must continue to expand their methods of instruction. I believe philosophical and psychological teachings can be interwoven with the teachings of mathematics. Getting into the minds of the students and changing perceptions and stereotypes regarding mathematics (and their own abilities to do mathematics) would be a step in the right direction. The importance attributed to sociomathematical norms stems from the contention that students reorganize their specifically mathematical beliefs and values as they participate in and contribute to the establishment of these norms. This claim implies that teachers can support their students' development of appropriate dispositions toward mathematics by guiding the development of sociomathematical norms (McClain & Cobb, 2001). Teachers of mathematics form a student's perspective about mathematics, whether intended or unintended.

Young (1906) puts the thought processes of mathematics into perspective regarding other chosen professions. If one wants to be a lawyer, learning to analyze a complicated legal case is similar to analyzing a simple proposition of geometry. If one wants to be a student of history, determining the influence of Napoleon on the world's development is like determining the influence of a coefficient in a simple relation of algebra. To be a linguist, translating a masterpiece, with its myriad shades of meaning, from one language into another corresponds to translating a trifling "reading problem" into the corresponding mathematical symbols. To be a physician, how will one diagnose and eliminate a disease, with its complicated, ambiguous, and obscure symptoms, if one lacks the faculties needed to identify and isolate the unknown quantity out of an elementary equation?

One does not necessarily want to take Young's comments literally here. I believe Young is trying to stress a point in the preceding paragraph. All jobs and professions require thinking skills and deductive analysis, unique to each, yet universally adaptable.

Hadamard (1945) believes one need not ponder on errors in mathematics. Good mathematicians, when they make an error, which is not infrequent, soon perceive and correct them and make many more of them than students do; only they usually correct them so that no trace of them remains in the final result. Errors can be conceptualized as part of the answers; students need to get over feelings of inadequacy and stupidity and learn from mistakes. Conversely, teachers need to give students "space" to explore, make and learn from mistakes. Wrong answers open the doors to questions, which in turn open the doors to discovery. Not being afraid of being wrong is a way to pursue the truth and attain enlightenment.

Teacher Instruction

Teaching could be defined as a performance art, and the audiences of the mathematics teacher are some of the toughest to perform for. Performers (teachers) should be introspective about their performances. One should analyze the effectiveness of one's teaching not only through student performance but also through self-reflection. According to Young (1906), the teacher of mathematics can by no means deal so leniently with himself or herself about the attribute that so many pupils have no interest in mathematics to an inherent lack of talent for it. It may be a tough pill to swallow, but mathematics teachers must face up to the possibility that one's method of instruction may be a contributing factor to a student's aversion to the subject.

Mathematics teachers need to realize that many students have feelings of incompetence toward mathematics and show empathy to those affected while working to reconstruct their psyches. Szydlik (2000) conjectures that some students' difficulties with mathematics stem from their sources of conviction. Ho et al. (2000) discovered that persistence rather than ability could account for differences in mathematical performance.

Regarding struggling students in mathematics, Young (1906) says that too often the mind of the pupil is held responsible for faults of instruction and Simon et al. (2000) believe no teacher has yet found the situation that affords students a clear view of mathematics. The teacher is

another tool to be used by the student. For the student to be successful in the mathematics classroom, should they not use top-notch tools? The dilemma becomes the production of top-notch (acceptably defined by society) mathematics teachers.

Self Efficacy

Studies have shown that math self-concept is related to math performance (Marsh, Walker, & Debus, 1991). Collins (1982) found that, when prior performance was controlled, children with high self-efficacy out performed children with low self-efficacy in the completion of novel math problems, showed greater effort, and persisted longer in reworking incorrect problems. Siegel, Galassi, and Ware (1985) found that a model that included self-efficacy accounted for a larger portion of the variance in math performance than did a model with anxiety and aptitude as the independent measures. An important finding to recognize is that students' judgments about their capability to solve math problems is more predictive of their ability to solve those problems than were other variables found by previous research also to be strongly related to math performance. For this reason, self-efficacy beliefs usually predict future behavior better than does past experience (Pajares & Miller, 1994).

Mathematics is often experienced as difficult but that does not mean mathematics is undoable. One can apply qualities and character aspects that make one successful in areas of his or her life to the task of learning mathematics. The same levels of self motivation, self-confidence, and work ethic that get one through life day in and day out can be applied to the endeavor of learning mathematics. It is safe to say that we are not all born with the same inherent mathematics abilities, but it is also safe to say that we are not born with a hatred, apprehension, or fear of mathematics. The where's, why's, and when's of students' dislike, fear, and apprehension toward mathematics will never be totally known and are probably continually changing, but some questions beg for at least a somewhat analyzed answer.

Young (1906) believes the simple reasoning of school mathematics can be understood by any normal mind if properly presented. He adds that it is hard to see how anyone really lacking such capacity could prove equal to the far more difficult reasoning demanded of him or her in any walk in life. Life is potentially full of far more complex problems than any mathematics text could offer. Young puts a lot of the responsibility of learning mathematics on the instructor. I disagree with Young here and contend that students are not necessarily taught; they must make a conscious effort to learn. One can lead the horse to water, but one cannot make said horse drink. Or in another sense, one can lead a student to mathematics, but one cannot make said student think!

Society is aware of the difficulties and frustrations existing in mathematics classrooms. The agenda now needs to focus on solutions. I would agree with Kirshner (2002) in saying that there is no magic "reform method" that addresses the multiple forms of learning that teachers may aspire to for their students, but maybe a good place to begin looking for answers is by listening to the students, who are living through the "nightmare."

In determining the origins of students' aversion to mathematics, instructors of mathematics will be able to gain insight into student perspectives on what makes mathematics difficult and unpleasant. The goal is to be able to address these concepts and concerns at their source. This study hopes to enlighten the mathematics community, parents, present and future educators on why students are coming into mathematics courses with dislikes of mathematics so firmly embedded in their psyches. A good place to combat a problem is at its origination. This study hopes to clarify some of the origins of detrimental attitudes toward mathematics in general.

Research Questions

Much has been written about attitudes toward mathematics (Dalton, 1986; Higdon, 1975; Stones and others, 1980; Trent, 1985; Troutman, 1978). It is well known that many students have a dislike for the subject. No prior studies have been found (this does not mean there are not some studies out there) exploring the origins of students' dislike for mathematics. I want to explore, from the students' perspective, the following questions:

1. When does a student begin to seriously dislike mathematics? (Was it a particular grade level, a defining moment, a specific grade or subject?)

2. Where does a student's serious dislike for mathematics occur? (Was it a particular subject of mathematics; was it a particular school?)

3. Why did a serious dislike for mathematics originate in a student's psyche? (Was it a particular teacher, a sense of peer pressure?)

These questions will be investigated through the qualitative analysis of the five open response questions filled out by Intermediate Algebra and Calculus II students.

METHODOLOGIES

Again I state, Young (1906) wanted people to realize that mathematics is an invention of the human mind. It is not an element found naturally, like oxygen, but a process that is refined through time. It is these processes (arithmetic, algebra, geometry, etc.) that make up the whole of mathematics. With so many students struggling with learning mathematics, studies need to be conducted to determine where the processes are breaking down.

Mathematics educators also need to be made aware of the efficacy and flexibility of students' alternative reasoning strategies (Nathan & Koedinger, 2000). Teachers need to be self-reflective, self-examining, and conscientious of the student's perspective. Jacobson and Lehrer (2000) produced findings that suggest that the student benefits (learns more) from having teachers who have knowledge attuned to nuances of student thinking within a mathematical

domain. According to Tirosh (2000), one conclusion may be that teacher education programs should attempt to familiarize prospective teachers with common, sometimes erroneous, cognitive processes used by students in working with mathematical problems. Borko and Shavelson (1990) back this up with a study which revealed that teachers generally report that information about students is the most important factor in their instructional planning, and teachers consider students' ability to be the characteristic that has the greatest influence on their planning decisions. Putting forth an effort to go inside the students' mind and getting to know the students' perspective seems to be paramount to successful mathematics teaching.

Open-Response Questions

Five open-ended questions were developed to allow participants a forum for expressing their feelings and opinions without restrictions or reservations. The questions are designed to elicit strong reactions, deep-seated thoughtful answers, and opinionated responses. This survey instrument may be the most important one to the researcher for it will offer mathematics educators insight into the feelings and thought processes of students.

Through these qualitative questions, I hope to interpret students' reality regarding negative feelings, attitudes, and outlooks toward mathematics. The aim will be to develop a theory, using grounded theory techniques, which may explain why students acquire a disdain for the subject (Newman & Benz, 1998). Human experience is unique to each individual and comes with interpretation. Theory building and inquiry, from a qualitative perspective, is a never ending process (Smith & Heshusius, 1986). This research will begin an ongoing inquiry into the where's, when's, and why's students acquire a dislike toward mathematics.

Multiple realities are to be expected in the qualitative portion of this research. Explicit explanations of the open-ended responses will provide the detail to "make sense" of the qualitative data (Firestone, 1987). The goal is to explore and construct a prevailing theme from the interpreted realities of the students' responses (Smith & Heshusius, 1986).

Qualitative (grounded theory) methods of coding and recoding were used in the analysis of the open response questions. Responses were coded and recoded separately for each of the five open-response questions. Categories were formed and themes (assertations) were proposed for each subgroup and each question.

For the sake of condensing this paper, the Researcher will be presenting just a few selected student quotes (of the 164) for each of the five open response questions.

QUALITATIVE ANALYSIS OF OPEN-RESPONSE ITEMS

Question One: Have the teacher(s) you have had for mathematics had any effect on your fondness or dislike of mathematics? How so? (Please give as much detail as possible.)

The first round of coding categorized respondents' answers in four ways. They were no, yes-positive, yes-negative, and yes-negative-positive.

No one from the Calculus II group gave a response which I considered to be in the "no" category. From the Intermediate Algebra respondents the general feeling I got was that a teacher does not affect their like or dislike of mathematics. A recurring comment focused on the student's inability to comprehend mathematics as witnessed by the following responses. The responses were recorded as close to verbatim as possible from the students' handwritten responses.

Table 1 generalizes the coded student responses that were chosen for inclusion in this paper.

Table 1:

Study Question	First round coding	Selected Coded Response categories
Q1: Have the teacher(s) you have had for mathematics had any effect on your fondness or dislike of mathematics? How so? (Please give as much detail as possible.)	No	no; strong
	Yes -positive	yes – positive
		yes – positive / environment
	Yes - negative	yes – negative
		yes – negative / sternness
		yes – negative / insecurities
		yes – negative / student perspective
	Long term effects	lasting negative effects
		lasting positive effects

The question elicited strong emotions from some of the respondents regarding how they feel about mathematics.

Question 1: Category: no; strong

"They don't make a difference even if I feel it is a good math class or he teaches well. I still have the same passion of HATE towards it."

This group generalizes that they just do not "get it." It appears their thinking is along the lines of logic versus creativity. Either one has the ability to comprehend mathematics or one does not have the ability. The learning of mathematics is more about them than the teachers.

The "yes-positive" category characterized traits of a teacher that were considered positive influences by the researcher. Respondents indicated that a teacher or teachers had a definite positive influence on their approach to mathematics for a variety of reasons. Some mentioned the enthusiasm, energy, and helpfulness of the teacher as a defining factor.

Question 1: Category: yes-positive

"Yes! My teachers have been a great influence over me. In 8th grade my teacher was very enthusiastic and helpful. In my senior year of high school I took and A.P. Calculus class and that teacher was very very good! She was always excited about math and constantly helpful - she always was stressing the beauty of mathematics and kept my spirits high most of the time!"

Being patient, explaining concepts clearly, instilling confidence in a student, and creating a positive learning environment were also deemed important aspects provided by a teacher.

Question 1: Category: yes-positive; environment

"Yes, all my teachers have had a great influence on the way I like Math. Junior High teacher told jokes while teaching to keep us alert. My senior high did a lot of examples & explanations - That is why I like math. Mr. Simmers is A great teacher."

" I think the single most important factor in learning mathematics is having a teacher who makes the experience positive. Even if you may not be "good" at math, if you have a positive experience you are more prone to not give up: not enjoy it."

One respondent gave a humorous, circular argument concerning a teacher's influence on his or her liking of mathematics. This student's response may lead one to deduce that if a student likes math the teacher may be a non-factor, but if a student does not like math, the teacher may be the reason.

"Yes and no, I have always loved my math teachers which helps keep me interested in the class, but at the same time I like my math teachers because I like math - so it is a toss up really."

It would be nice if all mathematics students had this unique quandary to occupy their minds. Characteristics of a teacher apparently play an integral part of making a mathematics classroom a pleasant environment.

The "yes-negative" category characterized traits of a teacher that were considered negative influences by the researcher. Respondents pinpointed what they considered detrimental teaching practices. Some of these included flying through the material and making it too easy to pass (too much extra credit).

Question 1: Category: yes-negative

"Yes, I can remember not hating math so much when I was in grade school up until 8th grade. I was fairly confident in math and did really well. Once I got to h.s. I started hating math. I really think it was because I didn't really grasp what was going on, and we moved to fast. My instructor would teach class then give us an assignment. He had placed the answers in the back of the class to check our work, but we did have to show our work to get credit. Anyway, I could just basically write anything and then circle the correct answer and he would accept it. So I did not need to know what I was doing and still got full credit. The reason why I think that was my turning point for disliking math was because I was allowed to sluff off. I got so far behind and passed a class without really learning anything, then when I actually had to do work then it was hard for me."

Having stern, harsh grading guidelines and being a coach who favored athletes were attributes that respondents frowned upon.

Question 1: Category: yes-negative; sternness

"My teachers in Jr. High were terrible! They were coaches and thought that their sports were more important than my math grades. My ninth grade algebra teacher was also my basketball coach if I had a crappy game he would be mean to me in class. He constantly called me stupid for not understanding what I was doing. So I think I would have had a much better experience with math if it hadn't been for these teachers."

"Most of them have made me dislike math even more. My past math teacher were stern, and really harsh graders. No matter how hard I try to like math, no matter how hard I study, Math just makes me freak out because of all my past math classes. I hate to think, that it's High School math, only harder. They always made it seem hard, they never used terms I could understand, and made it seem a lot harder then it probably is."

Processes that create insecurities in a student's mathematical abilities, make students feel stupid, and/or lower one's self-esteem really seem to affect the respondents in a negative manner. These processes could include saying grades out loud, the manner in which student questions are addressed, personal interactions with students, and student involvement, among others.

Question 1: Category: yes-negative; insecurities

"Yes, If I didn't like a teacher I usually did not pay attention resulting in the teacher disliking me and me disliking the teacher even more, it was a vicious cycle. Teachers can make you feel very inferior and yourself esteem is lowered and you don't participate in class. Therefore you don't let yourself learn."

One respondent's answer really showed that a teacher could have a very negative effect.

"The teachers I have had for math have definitely fueled my dislike for Math. I had the same teacher for Geometry and Pre-Calc in High school. This teacher used Methods that I did not understand. I so disliked this teacher that I would try to do bad on tests or not put in an effort to make him mad."

That a teacher could have this profound of a negative impact on a student's approach to mathematics is a revelation. An interesting psychological approach, doing poorly to make the teacher look bad. Imagine the implications later in life by this approach, either directly or indirectly.

A teacher is asked to play many roles in the education process. Some are accepted as part of the profession, but others are hidden in the myriad of human relations tied to the profession. A student's perspective of teaching is often quite different than the teacher's.

Question 1: Category: yes-negative; student perspective

"Before I came to college most of my math teachers weren't very good. I took almost all of the math classes offered by my high school & when I came here I was put in Math 102. I even took pre-calc. in high school. After taking all these math classes in high school you think I would at least be in 103. I really think my high schools math departments need to be looked at & changed."

What one student considers a lack of explanations, teaching one way, boring, or monotone might to another be perfectly comprehendible.

Specific grades and courses were mentioned often in these responses. The grade or course

was probably not as significant as teacher influence. The grade or course was a byproduct of running into the "bad" teacher. The wording used in many of this category's responses conveyed a respondent's "strong" feelings regarding teacher influence and attitudes toward mathematics.

The "yes-negative-positive" category revolves around responses that the researcher considered to have both positive and negative connotations. In this category, a teacher or teachers had both positive and negative influences on a respondent's like or dislike of mathematics. Again, specific grades and courses were often mentioned. From the respondents who seemed to have both positive and negative influences from teachers, the lasting effects tend to weigh heavily on the negative side, although some respondents had the positive effects endure for them. The negative influences tend to overpower the positive ones in their psyches for most of the respondents in this category. A sampling of the responses, separated into lasting negative effects and lasting positive effects, follows.

Question 1: Category: lasting negative effects

"if I asked a question. He would always say "Go look it up" or "At first I liked math, it was my favorite subject, then in 7th Grade I started Algebra and I had a teacher that would make me feel stupid "you should already know this". After about a month I stopped asking questions and gave up."

"My freshman high school year, my teacher made me o.k. w/math. She explained Algebra II very well. The next year in Adv. math, I had a bad teacher who just mumble what was out of the book and had no control over class. I fell behind and since math builds on what has already been learned I couldn't catch up. I loved math in elementary school.

"Yes, until my junior year of high school. My math teachers were very helpful & explanatory. My junior year I had a teacher who didn't explain the subject at all. Then, when you would ask questions he would accuse you of not paying attention. He wasn't available for any help outside of class either. It seemed as though he went out of his way to make himself unapproachable. This turned me off of math completely. I dreaded going to class. Once I got a bit confused I just gave up. He wasn't there to help and so I just stopped trying. The fact that I gave up was my fault, but I knew I couldn't get help from him. Yes, teachers had an effect of how I view math."

Question 1: Category: lasting positive effects

"Yes. The teachers I have had, have lots of effect on my fondness. In high school I pretty much hated math cause the teachers didn't care and I felt I couldn't approach them. So of course that made me scared to take extra math in high school that I probably should have taken, and therefore I was behind & also scared when I entered college. But with my courses I have taken here, I am not apprehensive at all to approaching the math instructor. I think teachers have a huge impact on how much kids like or dislike math."

"Yes. I have only had 2 teachers in "Math", 1 high school, 1 college. The H.S. teacher left me with negative feelings and a real dislike for math. (didn't explain things in terms I could understand. She was not helpful with questions.) The college teacher is more approachable, explains things in plain language that I can follow & understand, is available and interested in helping me understand what I need help with. With his teaching style he has helped me develop more positive feelings toward math."

The effects of teacher influence reach beyond a given classroom, course, or academic year and can have long lasting consequences for a student as evidenced by the following student response.

> "My teachers have had the most impact on my feelings towards math. They have after all, been the ones trying to teach me. In second grade is where my math troubles began. Teachers didn't help in long division, it took me a long time to become secure with that. Speed up time to 8th grade. My teacher was on a power trip, and I was armed with a calculator. Mental math disappeared as the school bought calculators and handed them out. We also started "integrated math" that year. We didn't have an algebra, trigonometry, calculus, or any specific courses. We were learning bits and pieces. I always had trouble with that. But my junior year I was a teacher assistant to a math teacher. She tutored me that whole semester and I became comfortable with math. My math class that year went great. I got my first A since early high school in math. It was also the last math class I took... That was my fault, but I didn't want to take math if I didn't have to. So now I'm at UND re-learning what I used to know, and as always, I feel I understand until test time rolls around. I study and review and feel good bout it, but some how still do poorly."

Data responses on the effects of teacher influence regarding feelings toward mathematics cover a wide range of courses and grade levels. Grade levels range from first through college, which means the course content covers arithmetic operations to calculus. This may suggest that the like or dislike of mathematics is influenced more by the teacher than age, grade, or course content.

The data from the three "yes" categories illustrate the importance of teacher influence, both negatively and positively, regarding a student's attitude toward mathematics. It seems as if a teacher can act as an "on/off" switch for a student's future perspective and outlook when it comes to mathematics. Luckily, it appears that the detrimental effects of one teacher can be overcome by the positive effects of another.

Question Two: Do you enjoy being challenged in some areas of your life? Please explain why these areas are areas where you enjoy being challenged.

Question number two was first coded into the categories no, yes and no, yes, yes with a sports emphasis, yes with an academic emphasis, yes featuring sports and academics, and yes featuring work or physical endeavors. What follows will be a qualitative look at some of these categories.

Table 2 generalizes the coded student responses that were chosen for inclusion in this

paper.

Table 2:

Study Question	First round coding	Selected Coded Response categories
Q2: Do you enjoy being challenged in some areas of your life? Please explain why these areas are areas where you enjoy being challenged.	No	no
	Yes	yes / not mathematics
		yes / academics; challenges
		yes / sports and academics; not mathematics

The "no" responses centered on a "comfort zone" associated with not running into any significant challenges and preferring it to be this way.

Question 2: Category: no

"I liked being challenged in some areas of life. I don't like being challenged in math."

A subdivision of the "yes" category found respondents liking challenges in all areas of their life with the lone exception being not in mathematics.

Question 2: Category: yes; not mathematics

"I like to be challenged in all things of life that will help me in my future. Most math will not."

Some "yes; academics" respondents expressed liking a challenge in subjects other than mathematics. Others enjoyed challenges just not regarding mathematics.

Question 2: Category: yes; academics; challenges

"In most areas so I get a feeling of accomplishment. Math is just such a struggle (a play I can't read)."

"YES I LOVE A CHALLENGE, I JUST HATE FAILING THIS CHALLENGE CONSTANTLY"

The "yes; sports and academics" subdivision also had a group of respondents who enjoyed being challenged as long as it was not in mathematics.

Question 2: Category: yes; sports and academics; not mathematics

"I really enjoy being challenged in my life physically and creatively, math makes me feel like I am to bound up into following the rules and coloring inside the lines you cannot be creative just follow the rules and you'll get it."

A summary of question number two finds a majority of the respondents do enjoy being challenged in many areas of life. A common subdivision among the categories was enjoying a challenge in areas other than mathematics. It appears that respondents do not want to perceive learning mathematics as taking on a personal challenge. Math seems to be a mirror to one's soul.

The analysis of one's math capabilities may be an indicator of one's fortitude, resilience, as well as other personal characteristics.

Question Three: What do you feel is the single most important factor in learning mathematics?

Question number three's first round of coding yielded a wide variety of factors deemed important by the respondents. A total of 22 categories were introduced through the initial coding process. A sample of the 22 includes memorization, attendance, practice, teacher skills, and understanding. The next recoding phase combined and shuffled the initial 22 categories, resulting in 8 interpretable categories. I have labeled these confidence, memory, teacher, pace, attendance, homework, thinking, and miscellaneous. The miscellaneous category consists of calculator usage, age relations, book selection, and group interaction.

Table 3 generalizes the coded student responses that were chosen for inclusion in this paper.

Table 3:

Study Question	Selected Coded Response categories
Q3: What do you feel is the single most important factor in learning mathematics?	Confidence
	Memory
	Teacher
	Attendance
	Thinking

The "confidence" group thought confidence, not giving in to a fear factor, and approaching mathematics with a positive attitude were important factors in learning mathematics.

Question 3: Category: confidence

"I think you need to have confidence. I don't think you have to love math to be confident in this area. I also think that it should be taught a little slower. If someone is not to great in math and it is also very fast paced, well a student becomes overwhelmed and most of the time gives up develops a hatred for math. I also think that if we are not allowed to use calculators in our higher ed. classes then we should not be able to touch them while we are in grade school."

Different areas of importance stressed by "memory" members are a person's capacity to memorize, having a firm grasp of the basics, the ability to stay focused on the material at hand,

and maintaining a high level of concentration.

Question 3: Category: memory

"paying attention at all times and remembering. There are so many little things that you need to know."

"Memorize, memorize, memorize. There are so many little details in mathematics. The only way to get them straight is to memorize when and where they are used."

The "teacher" category revolved around what respondents perceived as valuable characteristics the instructor should possess. Some of these included the ability to communicate effectively with students, consistency, clear explanations, and organization in the presentation of material.

Question 3: Category: teacher

"having a teacher that makes learning pleasurable, because then it makes me want to come to class and try harder."

"That the teacher listens to the students, and the student comes in with an open mind, and the student puts work into understanding math."

"Has to be the teacher's ability to make the subject matter easier. Take complex methods and brake them down into easy to learn steps."

"Having a teacher that can communicate with their student very easily. They have to be able to explain mathematics in terms their class can understand."

"Attendance" respondents felt that an individual being present in the classroom was essential for the learning of mathematics to occur. Asking questions, no matter how trivial they may appear, and getting them answered is also an important factor in this group. Willing to commit the time required to comprehend material and being patient are more vital components to learning mathematics for this group. Too often, students underestimate themselves and their abilities. Teaching mathematics may be more about teaching confidence.

Question 3: Category: attendance

"QUESTIONS! ASK THEM AND GET THEM ANSWERED"

"For me it is patience and repetition. I tend to get impatient with math."

Answers in the "thinking" category range from "there is no single important factor" to "it (mathematics) is all around us." Possessing skills in the art of thinking also falls along the spectrum of important factors contributing to the learning of mathematics for the "thinking" group. Students appear to know what it takes to do well in math, but too many are not doing it consistently.

Question 3: Category: thinking

"I think that math makes you smarter in all areas of your life. Not only do you learn the very important skill of arithmetic, but you also learn critical thinking skills & how to challenge your mind. You can apply your math skills in many aspects of daily living. It also teaches you to work hard & that you need determination."

Question number three responses illustrate the wide variety of perspectives individuals hold when contemplating the learning of mathematics. Even a relatively small community of people (164 students) can vary significantly in their viewpoints and opinions.

Question Four: In your opinion, what makes mathematics difficult to understand or easy to understand?

Question number four responses are similar to those from question number three. There were a handful of respondents who believed mathematics is easy to understand. Their reasons for mathematics being easy to understand paralleled those who believe mathematics is difficult to understand. For example, "I think mathematics is made easier when the teacher takes the concepts and puts it with real life . . ." is from an answer categorized as easy to understand, while "What the hell is X and Y? I don't think I will ever use it in my life." comes from an answer categorized as difficult to understand.

Coding of question number four initially broke down the responses into three categories: viewing mathematics as difficult to understand (difficult), viewing mathematics as easy to understand (easy), and those who gave reasons for mathematics being both easy and difficult to understand (easy and difficult). Within these three categories, 28 subcategories were identified. The 28 subcategories were combined and condensed within the three main categories.

The "difficult" category now consists of five subcategories identified as "memorization," "background," "teacher," "overwhelming," and "applicability."

Table 4 generalizes the coded student responses that were chosen for inclusion in this paper.

Table 4:

Study Question	Selected Coded Response categories
Q4: In your opinion, what makes mathematics difficult to understand or easy to	Memorization
	Background

understand?	Teacher
	Overwhelming
	Applicability

Important aspects in the "memorization" category include, obviously, memorization, recognition, and patience. Respondents are concerned about the amount of material that needs to be memorized, being able to distinguish between different types of mathematical problems (they all look the same), and the time and effort involved in becoming proficient at mathematics. A circular argument can be constructed around these three premises. It takes time and effort to memorize, but once procedures are memorized it will save time in the recognition and working of problems. Many facets of life are based upon memorization, spelling, phone numbers, tying shoes, et cetera.

Question 4: Category: memorization

"To me most problems look the same. When I look at a problem to see what type it is. All I see is a mess if #'s and variables. I think I find it too overwhelming."

"The speed & memorization required. - then the expectations that you know it perfectly."

The "background" category consists of an array of principles that have led respondents to find mathematics difficult. Respondents named having a poor background (weak foundation) along with poor study habits as factors contributing to difficulties in mathematics. A dislike of working with fractions and having a general laissez faire attitude toward mathematics were also mentioned by respondents in this grouping.

Question 4: Category: background

"It is difficult to understand, for, me anyways, because through most of junior high, and high school I had poor study habits in math."

Question number four elicited responses regarding qualities associated with an instructor of mathematics in the "teacher" category. Skipping steps (even what might be considered the most obvious to some), going through the material too fast, coupled with what students consider bad explanations foster feelings of difficulty in the learning of mathematics. Respondents suggested that different learning styles contribute to mathematics being difficult. One individual prefers one-on-one instruction, mentioning that it is absurd to have large class sections. Another

felt with good explanations, understandable examples, and clear notes learning mathematics should be a breeze.

Question 4: Category: teacher

"It's easy if there is a good teacher that makes it fun."

"It's Difficult because I have always had a bad teacher."

"It's difficult because teachers sometimes go to fast, and say things like "Oh, this is so easy" but it's not that easy for some people and they don't understand that."

Within the "overwhelming" category, subcategories such as intimidation, too much practice, too many steps, too many rules, one mistake ruins things, lacking confidence, being irritating, and falling behind prevailed. All of these are quality observations. One "little" mistake can ruin things; this, in turn, may lead to low levels of confidence, feelings of intimidation, and create sources of irritation. It can also be said that mathematics entails a myriad of rules, processes, and procedures which may enhance feelings of inadequacy, and the possibility of falling behind is a real threat to a student's ability to comprehend mathematics. One respondent compared the feeling of falling behind in a mathematics class as "drowning myself in a sea of equations". Mathematics should not be about answers, but the processes that lead to solutions.

Question 4: Category: overwhelming

"What makes math difficult for me to understand is that most of the time math has lots of equations and steps which can make me feel overwhelmed. Since I couldn't understand the material and I couldn't get help to understand the material, I began to lose a lot of confidence in my mathematical abilities and began a strong dislike of math."

Subcategories making up the "applicability" category include; mathematics not being applicable to daily life (where will I ever use this), the left brain-right brain debate (one either "gets" mathematics or one doesn't), the confusion of why variables are implemented and not just numbers (what are x and y) , and the idea that mathematics is akin to a foreign language (it is so different).

Question 4: Category: applicability

"What the hell is X and Y? I don't think I will ever use it in my life.

Question Five: If you find yourself liking or disliking mathematics, can you pinpoint where, when, and why the like or dislike started? Please give as much detail as possible regarding grade level, teacher(s) (styles, comments, etc.), subject matter (arithmetic,

algebra, geometry, etc.). (Please use back of page if more room is needed.)

Question number five was first divided into groups of respondents who liked mathematics, those who did not like mathematics, ones who both liked and disliked mathematics at different periods of their education, and still others who once liked mathematics but now dislike mathematics. The "dislike" category was broken down further into six prevailing themes. These are, in no particular order, elementary, middle school/junior high, high school, geometry, teacher, and potpourri. For this research, elementary will consist of grades 1-6, middle school/junior high will consist of grades 7 and 8, and high school will cover grades 9, 10, 11, and 12. The last three categories–like, like/dislike, liked now dislike–will be considered as separate and singular units.

Table 5 generalizes the coded student responses that were chosen for inclusion in this paper.

Table 5:

Study Question	Selected Coded Response categories
Q5: If you find yourself liking or disliking mathematics, can you pinpoint where, when, and why the like or dislike started? Please give as much detail as possible regarding grade level, teacher(s) (styles, comments, etc.), subject matter (arithmetic, algebra, geometry, etc.). (Please use back of page if more room is needed.)	elementary
	middle school / junior high
	high school
	teacher
	potpourri
	like
	like / dislike
	liked now dislike

The "elementary" category was aptly named for respondents whose dislike of mathematics started sometime during the elementary grades. Struggling with the "basics" of arithmetic (i.e., multiplication tables, long division, and subtraction) appears to be hurdles that could not be overcome for some. Receiving no positive feedback (i.e., smiley faces on returned homework) and teacher remarks that ridiculed and caused embarrassment to the student were determining factors that fueled the dislike of mathematics for some of the respondents.

Question 5: Category: elementary

It was in elementary school 6th grade. I got my "papers" back and the only subject that did not have a

"smiley-face"(picture of smiley-face) was math! From that day on I have always thought that I could never be good in math!

Yes, a dislike for math in third and fourth grade. They would use uncomfortable remarks toward student in order to embarrass them if the answer was wrong. Would punish those who did not understand. I formed a dislike for basic math.

During the "middle school/junior high" years, the introduction and applications and theorems created frustration for respondents. The lack of making homework assignments mandatory and the lack of supervising the completion of homework assignments (i.e., allowing homework to be copied, working at one's own pace) left respondents lagging behind in mathematical skills. For the lack of a better term, I will call the next theme "tracking." Respondents were "turned off" from mathematics by being enrolled in what was perceived be lower-level mathematics courses.

Question 5: Category: middle school/junior high

After the 7th grade I was put in the lower math class and I always got made fun of and I've hated math ever since.

My dislike started in Junior High because math started getting a lot tougher and that's also when there would be different levels that students could take and it would make you feel less superior to be in a lower class than others.

In the "high school" category, respondents were intimidated and shied away from asking the teacher questions. Having low expectations of one's own performance in the area of mathematics deterred some respondents. One actually is quoted as saying, ". . . I have never got a good grade in math and just don't expect myself to." Having a teacher who only focuses on the "bright" students or one who is incompetent or limited in the art of teacher/student relations can also be a deterrent for students.

Question 5: Category: high school

My dislike started in high school when I was too scared to ask questions and I felt like the teacher would think I was dumb if I asked a stupid one. I sort of gave up. But when I came to college, I was not scared to approach the professors or ask questions. I just learned so much better that way. If I don't like a teacher or how the teacher teaches I don't like to approach them, so it kinda makes a huge difference on how well you enjoy the teacher or their techniques.

My dislike of math started my freshman yr. of high school. The first math class I had (Algebra) was awful for me, and I can't remember if I dropped it or not, but I certainly tuned it out. The first couple of weeks were okay, but when the problems became more complicated and I needed some assistance I ended up feeling out in the cold. The teacher was not receptive to questions. I can remember being told "It's just done that way" when I asked why something was done a certain way. And "It's simple, why don't you get it?" when I asked how something was done, She wouldn't go thru step by step when I asked how & why so I could understand. That left me very frustrated. I didn't feel I could ask for help, and I didn't have anyone else to ask. So, I stopped asking questions (that never really got answered anyway) and stopped paying attention since I wasn't getting it anyway. The teacher did not notice or care, so I just let it go, to "never" look back on it again. Or, so I thought. Anyway - that's where my dislike, fear, and anxiety over math comes from. I hit a really big road block back then. Until now that was the only Algebra class I'd ever taken and I have never worked thru that fear of failing at something.

Habits and teaching characteristics of the instructor prompted many students to have feelings of dislike toward mathematics. Some respondents felt intimidated and uneasy when they were singled out to answer questions, others believed a teacher was biased toward particular individuals or groups of students. Having a teacher exhibit a lack of confidence in a student's ability led to low self-confidence for some respondents. One "bad" teacher had more influence on respondents' feelings toward mathematics than a handful of "good" teachers. Respondents appear to feel that a teacher's ineptness concerning the subject matter, ". . . I think he knew as much about math as me . . .," makes approaching them with questions a futile endeavor.

Question 5: Category: teacher

I started to dislike math when I was a freshman. I was supposed to be in Algebra. I told the teacher I didn't understand the end o f the first week. He didn't try to help me understand anything so I took Consumer math (Bonehead math). The fact that the teacher from Algebra didn't try, really made me feel intimidated. He must've thought I couldn't do it, so I did too.

Algebra, Senior year of H.S. I had a horrible teacher who didn't care if anyone passed her class. So she never made herself available for help after class hours. She didn't like me personally because I played sports and she hated athletes. She thought that we were there to get a good enough grade to stay eligible, not to learn.

My dislike of math came, I think, in 8th grade with my teacher Mr. Virgin seeming not to really care how we did and his constantly saying that he gets paid even if all of us did poorly. Every math teacher I've had since him have generally been good teachers but doing poorly in Mr. Virgins class meant that I and lots of others in my grade had to take geometry again in 9th grade. Retaking a subject I think has also contributed to my dislike of math.

Varied responses with no real connecting theme landed in the "potpourri" category. One of these centered on the notion that just because an individual is competent in mathematics they assume everybody should be competent. Another was bipolar in its description; liking mathematics when one did well while disliking mathematics when one does poorly. One

respondent just cannot comprehend the "middle" steps to get from A to D in a particular problem. No matter how "easy" steps B and C were, the connection is not apparent to this individual. General non-interest toward mathematics (would rather be doing something else) also contributed to a dislike of the subject.

Question 5: Category: potpourri

When a particular person is good at math they seem to expect that everyone else is too. for some people it doesn't come that easy. But the people that are "good" at math make you feel stupid for not knowing it. (I don't think they do it on purpose or maybe they do.) this is very discouraging. And then you get a couple teachers that suck and it ruins it and makes it harder later on.

My dislike started when I began to receive bad test scores. I would study and study and then fail the test because I used a negative instead of a positive. etc. I don't think teachers had any affect on why I dislike math. You always have new teachers. You begin to hate things when there is no positive reward. When I got low test scores I hated math. When I got high test scores I loved Math. When the work you do pays off you enjoy math.

Characteristics associated with a teacher, mathematical games played in the classroom, and characteristics associated with mathematics make up the content of category "like." Respondents enjoy mathematics when a teacher is "cool," has a positive, pleasant, upbeat attitude; and is receptive to questions. Making students feel at ease with mathematics and presenting material in a manner that brings mathematics "down to their level" are teacher traits considered important to this group. Mathematical games, like "around the world," enthused respondents and solidified their appreciative attitude toward mathematics. The organized structure and preciseness of mathematics stimulates respondents' brains, making them think and in turn fostering their positive feelings toward mathematics.

Question 5: Category: like

I started liking math when I started this class. Mr. Simmers' attitude makes math enjoyable and comprehendible. He shows steps for individual problems to make problem comprehendible. Also he takes adequate time to answer questions, and most importantly he takes time to teach. It makes a difference when the teacher likes to teach, then students want to learn.

I think my original attraction for math came in grade school when we did times tables. We had to do 100 problems mixture of addition, subtraction, multiplication, and division as fast as we could. I became fairly good at these tables and ever since then I have loved math. My (Algebra I) eighth grade math teacher had battles doing our test girls average vs guys average and the winners had to serve the losers pizza - I know this got the guys & girls studying alike. I think the key to liking any subject is understanding the subject and having fun.

In 8th grade I came to love algebra! My teacher was awesome and he was so helpful - he took the time out to help you. Although I disliked geometry very much because the teacher was not clear in her explanations and consequently was hard to listen to. That was in 9th grade. But ever since 8th grade I have liked Math - at times calc can be very intimidating but I still enjoy it. I learned that I love math in my Senior year when I took the A.P. Calculus class, it really was a fun and challenging year because of the teacher! I think that the teacher is the most important factor in a student finding if they like math or not!

Respondents in the "like/dislike" category exhibited a correlation between subject matter and teacher. One liked algebra and also liked the teacher for this class, but disliked geometry and the teacher of geometry. Others' like and dislike revolved around a "good" teacher for some class versus a "bad" teacher for another class. One respondent turned from a "math hater" to a "math enthusiast" because of her or his pre-calculus teacher. This teacher instilled confidence in the student to solve mathematical problems by her or himself and took the fear out of mathematics through his teaching style. Some respondents' like or dislike stemmed from particular courses. They either considered the course to be a "good" subject or a "bad" subject. Motivation or lack thereof instilled like or dislike of mathematics for some respondents. If they found relevance in the subject matter, this would motivate them to learn whereas irrelevance resulted in the lack of motivation to learn.

Question 5: Category: like/dislike

I started to not like math in jr. high, but then I got better teachers 9th & 10th grade year. They taught well, and were very understanding. They got to know you personally. Then 11th & 12th grades in HS, I got bad teachers. It was their way or now way and they had no sympathy if you didn't understand the materials. It was geometry & algebra.

I find myself liking math! I turned from a "Math hater" to a "Math enthusiast" in 8th grade. In grade 10, I took Geometry & decided I wanted to be a Math teacher. I loved Geometry because I could visualize it. I could understand it & did very well. I actually liked doing my homework for Geometry. My teacher was very good & explained things well! Geometry was totally interesting to me, I was fascinated by it. As a senior in high school, I took Pre-calc. I did not do well, but still enjoyed it. My teacher was the reason I enjoyed Math even if my grade was not good. He had a very unique teaching style. He never lectured or did problems for us. He directed the class to the solution, but we developed solutions. This was helpful because students developed solutions instead of him showing us. He always made students go to the board to do problems & they had to explain the solution We were learning from each other, which really brought it down to our level. He gave me the confidence to try to solve Math problems on our own. He took the fear of Math out of students by teaching this way. I still enjoy Math, but find it very difficult. I am a Math Education Major. I still struggle with math, but I am focused on being a teacher. I still enjoy math classes, so I hope that my enthusiasm and love of math will help me be a better teacher one day.

The "liked now dislike" category is a disturbing one for the researcher. What turned these respondents away from mathematics was the inability to receive help when they were confused,

which resulted in lost confidence in their ability to perform mathematical computations. Teacher inflexibility, ". . . teacher would want us to do it his way only . . .," changed some respondents from "likers" of mathematics to "haters" of mathematics. When mathematics fails to be "fun" or interesting, either because of the subject matter or the teacher, respondents converted from liking mathematics to disliking mathematics.

Question 5: Category: liked now dislike

I started to dislike math my freshman year. I was taught one way to do things & the teacher would teach us another way & want us to do it his way only. I didn't understand their way. Also, my geometry teacher was bad. I used to love math in grade & middle school, now I hate it!

INTERPRETATION OF RESULTS

Interpretation of the open-response questions will be divided into categories deemed, by the Researcher, as influential areas affecting student attitudes toward mathematics. More student quotes are mingled in with the commentary.

Learning First Alliance

The Learning First Alliance (1998) is an organization that believes to simply require students to take a standard high school algebra course in seventh or eighth grade is an approach that needs revamping. One respondent regarded algebra with apprehension: "looking at a pile of roots, x's, y's, radicals, x^{-1}'s it scares me to death." Learning First Alliance would rather see K-9 curriculum restructured to allow for a more coherent transition from elementary school mathematics to higher-level coursework. Casey et al. (2001) think that, to have long-term and significant effects, the teaching of these ideals should start at the kindergarten level or earlier.

Data from the open-response questions suggest that students generally enjoy mathematics during their elementary years. I suggest we introduce the concepts of algebra (representation of numbers using variables) at the kindergarten level. This is where children are introduced to the numbering system, counting, adding, and subtracting, along with other concepts. In general, kindergartners know that they can add one pencil plus one pencil but cannot add one pencil plus one truck (the researcher acknowledges that the addition of the two objects is possible as two

"things" but uses the analogy to emphasize a point). This could be extended to include x's, y's, z's (letters). One important aspect, I believe, is to not refer the processes being taught as "algebra," which could be interpreted as a confusing and intimidating term, but to simply add and subtract them like any other objects. Terminology can wait for the more educationally mature years.

Pace of instruction and the amount of content covered in courses are also issues addressed by the Learning First Alliance. Students also voiced their concern regarding these issues through this study. "Teachers move way too fast for me and I get lost and fall behind.," "Moving slow. The teacher should make sure everybody understands before they move on.," "It is so frustrating to go through a whole class period not understanding & knowing nothing, especially when the teacher goes too fast.," and "I think what makes math difficult is racing through the class and not spending enough time on understanding what you are learning." are a few comments presented by students concerning the pace of instruction.

Studies have shown that Asian students differ from U.S. students with respect to attitudes, beliefs, and emotions regarding mathematics (Ho et al., 2000). A possible underlying reason for these differences could be found in the students' remarks from the previous paragraph. The frustrations experienced by students in the U.S. regarding mathematics may be a direct consequence of the pace of instruction and the breadth of content covered in the courses.

According to the Learning First Alliance (1998), research into the structuring and delivery of mathematics instruction in other nations suggests that at each grade level students take relatively fewer topics but cover them in greater depth, so there is no need to include a given topic every year through eighth grade. In comparison, many topics are repeated at many grade levels in the United States of America. The Third International Mathematics and Science Study (TIMSS) found that U.S. textbooks cover a broader range of topics every year until ninth grade than 75% of the 43 TIMSS countries.

Students have grievances based on the findings of the Learning First Alliance as evidenced in the following student quote:

> "I think I started to really dislike math when I was in high school. I didn't understand it, and my teachers would fly through every lesson. I hate how teachers HAVE to get through a certain amount of information in the semester because every class is different. Maybe one class has a lot of people who love math and are good at it....but not every class is going to be like that. So go w/your class not w/what you HAVE to get through I think that would help a lot."

In defense of teachers, a lot of the complaints coming from the students is not directly in their control. Class size, pace of instruction, accommodating different learning styles, accounting for the absorption of knowledge, and rate of learning for individuals are often mandated to teachers.

If students are perceptive enough to pick up on nuances affecting their mathematical education, when are administrators and policy makers going to recognize and act upon possible changes that could be made regarding amount of course content covered which directly affects the pace of instruction? Research should not be taken as total truth and blindly accepted, but it does have to be regarded intellectually and openly for its possible benefits.

No Child Left Behind

Many open-response answers from the students talked about a teacher's lack of knowledge in the field of mathematics as having a significant influence on their view of mathematics. According to the Research Advisory Committee (2000), low socioeconomic status (SES) schools have 31% of their K-12 teaching staff, whose main teaching assignment is mathematics, owning neither a major nor a minor in mathematics. I would venture to say that this condition could be extended to other categories of public and private schools throughout the nation.

The Elementary Secondary Education Act (ESEA) (commonly referred to as No Child Left Behind) is designed to discourage the hiring of teachers who lack expertise in their content areas and will supposedly remedy this ailment. It calls for each state receiving funds under Title

I, Part A, to develop a plan to ensure all teachers of core academic subjects within the state are "highly qualified" by the end of the 2005-06 school year. Teachers at the K-12 level, first and foremost, should have thorough command of the subject matter that they teach. All too often the mind of a pupil is held responsible for faults of instruction. A student's brain is full of curiosity, seeking to know and to discover. Instead of furnishing food for this curiosity, mathematics teachers (some by title only) often weaken and discourage it by imposing a sort of intellectual obedience on the mind (Young, 1906).

Two scenarios unfolded regarding teacher qualifications through students' answers to the open-response items. One regarded the disdain felt toward an unqualified mathematics teacher.

> "I like algebra but I have had some bad teachers in the past that made Math hard. Like my 7th grade teacher Mrs. Sanders. Never taught we taught ourselves for Algebra. Or my 10th grade teacher Mr. Tabbot. Never taught either. It annoyed me to watch him sit at his desk and play on the computer while we taught ourselves"

Another felt that the mathematics teacher had a superiority complex and could not teach to the "students' level."

> "Mr. Holen, my junior year Algebra II teacher is who made me dislike math. He was unapproachable, monotone, rude, gave horrible examples and notes. He also sang this square root song that still gives me nightmares. Mr. Holen was a very unpersonable guy who seemed to complicate everything about math. Almost as though it was because he liked being smarter."

A struggle regarding the teaching of mathematics (or any subject matter) is that there is no one "best" or "correct" method that affords students a clear view of the subject (Simon et al., 2000).

The profession of mathematics educator is not really any different than other professions in the point that there will probably always be poor mathematics teachers and excellent mathematics teachers. Just like there exist carpenters with poor skills and carpenters with excellent skills (insert any profession one desires) throughout the United States of America, or the World for that matter.

If the ongoing improvement of mathematics teaching is to become a reality at the classroom level, teachers must assume a proactive role and be key figures in changing the ways

in which mathematics is taught and learned in schools (McClain & Cobb, 2001). Teachers need to be self-reflective, self-examining, and conscientious of the student's perspective. Jacobson and Lehrer (2000) found that students benefit (learn more) from having teachers who have knowledge attuned to nuances of student thinking within a mathematical domain. Teacher education programs should attempt to familiarize prospective teachers with common, sometimes erroneous, cognitive processes used by students in working with mathematical problems (Tirosh, 2000). Putting forth an effort to go inside the students' mind and getting to know the students' perspective seems to be paramount to successful mathematics teaching. Mathematics educators need to be aware of the efficacy and flexibility of students' alternative reasoning strategies (Nathan & Koedinger, 2000). By doing so, it will create flexibility in their own presentation of the material and assessment of student performance.

Teacher Characteristics

Students' responses frequently contained references toward teacher characteristics that affected their like or dislike of mathematics. Students want teachers to deliver subject material clearly and concisely. They want teachers who are energetic, enthusiastic, and knowledgeable.

Teaching effectively is a demanding endeavor, and the performance requirements placed upon a mathematics teacher are some of the toughest when faced with the multitude of negative feedback as represented by the student responses from this study. The large number of respondents disliking mathematics because of teacher influence must have some sort of credence. Way back in 1906, Young believed that the teacher of mathematics could not deal leniently with oneself in displacing the blame for so many pupils having no interest in mathematics on an inherent lack of talent for it. It may be a harsh reality, but mathematics teachers must warm up to the possibility that one's method of instruction, personality, and knowledge may be contributing factors to a student's aversion to the subject. Young (1906) goes on to say that the majority of pupils do not find mathematics simple or easily evident. "This," he

says, “does not point to any inherent lack of simplicity in the subject matter, but to a disregard of its real simplicity in the presentation and study” (p. 128). One respondent illustrates both perspectives of how a teacher’s presentation, personality, and knowledge can shape one’s perception of mathematics for the better or worse.

“four times I disliked math	
3rd grade	learning touch points I thought was stupid
7th grade	this time in life for a teen is hard enough for a child not to mention we had a teacher that should have been teaching in college so it made it that much Harder
8th grade	We had to take notes on terms and we would have quizzes on the terms to me math is not about remembering terms its about doing problems I think this is the year it all went South so to speak. I didn’t pick up on much of the Pre algebra in this class
10th grade	Again we switched Math teachers but this teacher seemed to care and would explain it to us as many times as we needed and as many different ways that he needed to so it helped knowing that if I needed it I could get the help
	Freshman year in college aka this year I’m learning what I didn’t learn in 8th and 9th grade and now it is all starting to make sense again Math is a subject that I can take or leave I don’t hate it but I don’t love it either I’m indifferent to it.”

Thinking an instructor is “good” and/or liking one’s mathematics instructor can affect the motivation of students, both intrinsically and extrinsically. “I feel that the single most important factor is having a good teacher. W/o a good teacher students don’t want to learn. If the teacher is good he/she will help the students who are having trouble.” The external motivation of liking one’s mathematics teacher may produce higher levels of intrinsic motivation in the form of wanting to do well in his or her class. In the quest to get students interested and confident about mathematics, every little positive reinforcer is beneficial. As one respondent remarked, “When you are a child learning math, you need to have a great teacher and you’ll love math forever.”

Left-brain, Right-brain and Applications of Mathematics

Respondents felt they were confined by the many rigid rules of mathematics. Some felt a lack of opportunities to create and express themselves through mathematics. “Its difficult because there’s so many rules you have to follow. You can’t be creative–its very detailed & strict,” “The fact that you go from one type of Math to another, and they aren’t the same. Ex. Algebra & Calc,” and “I do not understand it there are all these little rules to learn which I am

terrible at. What there should be is creative mathematics." These respondents appear to be naive about the workings of mathematics.

First of all, mathematics is a creation of the human mind. Numbers and mathematical concepts are not elements found naturally like oxygen, so the invention of mathematics was a creative endeavor. Other subjects (English, speech, spelling, composition, et cetera) and civilizations have guidelines and rules (traffic, moral, and ethic guidelines and laws, for instance) that one's creativity must stay within the bounds. Referring back to previous sections, a teacher's demeanor and flexibility can affect a student's creative approach to mathematics.

Respondents also felt that no matter how much they tried, got help, and studied, the ability to successfully perform mathematical operations would still elude them.

> "Well my sophomore year of high school I was in algebra and, though I had a great teacher, I was failing. I got a tutor and still was not doing very well. I couldn't really understand why I was doing so poorly which is why I get flustered by math now, because I am worried that I will do that poorly again and not be able to find out why or correct it in any way, in result getting bad grades."

Some are just waiting in vain for "the light bulb to turn on." "When you do or don't understand the math problems. You are always waiting for that 'click' in your head and it is up to you if it stays off or turns on!"

For me, an answer to this is to teach study skills for mathematics. The study of mathematics needs to be approached differently. It does need continuous effort. Cramming for a mathematics test is not likely to be a good method of preparation for most students. The organization and memorization of techniques, processes, and steps needed to successfully complete different types of problems, for me, reduces the working of many mathematical problems, at the undergraduate level, into a series of steps involving arithmetic operations (which most students are quite competent at performing).

The application of mathematics, beyond adding, subtracting, multiplying, and dividing, emerged, through data analysis, as a prevailing theme by respondents.

> "The most important thing about learning mathematics is so one has an understanding of how things work. What I don't feel is important is learning mathematics that is irrelevant to one's life or career. For example,

> I am an aviation major, so why do I have to learn calculus? All of the math I need for calculating events and situations is basic addition, subtraction, multiplication, division. Where does calc even fit in?"

The mathematics community needs to answer the question, "Why do students majoring in aviation, business, marketing, and management have to take mathematics courses?," with a succinct and meaningful response. Students in the non-math, non-science degree fields need to hear it from professors in those departments why mathematics courses are part of their curriculum.

Judging by the respondents' open-response answers, many students are disillusioned with where mathematics is used in "real life." "When it got to the point where it was useless for most people. (Not in a profession that needs it)" is how one respondent described why his or her dislike of mathematics started. Another believed that just knowing how to add, subtract, multiply, and divide is enough.

> "I think my dislike of math started in grade school, when everyone else in my class seemed to understand what we were doing, except for me. From then on I have never liked math. I have never had a teacher that has made it easy for me to learn, they always spoke with big mathematical words that I never understood. The only thing that I am good at are adding, subtracting, multiplying, and dividing. I also find math to be a very pointless thing & completely useless, unless your going to be a mathematician or something. I think as long as you can do the basics, add, subtract, x, & /, you are set to go in life."

One respondent thought there was nothing to gain from the study of mathematics.

> "I liked and was in advanced math in elementary school, but in Junior high the teachers began assuming we knew things about math we didn't and it became hard. I have trouble taking and interest in math as well, you can't learn anything from it like you can in English or Science."

One could ask, how many people actually use science, history, English, et cetera in their job duties on a daily basis? Another respondent went so far as to say that mathematics teachers are out of touch with the "real world" (and have been for generations), and the student was informed of this from his or her dad!

> "School teachers haven't been in the real world as my dad would say. They were taught school by someone who hasn't been in the real world either. - You maybe an exception to the rule as you build houses &/or have a business. The teachers that have been in the real world - inspire us & we have a greater respect for because they can show us how to relate subjects to the real world. You never learn in school how to figure how much cement mix you need to cover a 60 x 80 plot - and actually tell us we <u>could</u> someday want to build a shop & this is how much it would be. Practical stuff. How do you figure out any type of material for a project?"

Some respondents were on the flip side of the previous paragraph's coin and believe in the widespread applicability of mathematics. One thinks mathematics is complicated but

essential to "getting ahead." "I think that it is important to learn because the world's economy revolves Around it. It is complicating but you need to know otherwise you won't get far in life." Another knows other disciplines are mathematically based, but has a hard time finding everyday uses for calculus.

> "I think that having a lack of real world applications makes it difficult. For example, in Physics, every problem done involves a real-life situation. I know Calculus is the basis for Physics, but it is hard to apply Calc to every day life."

This section leads me to believe that the field of mathematics needs work in its public relations and marketing departments. The image of mathematics out there (to what seems to be the majority) appears to be one of eliticism, superiority of intelligence, inapplicability or lack of purpose, just to name a few. I am not a fan of the adage "image is everything," but it seems applicable in the area of mathematics. Ad campaigns promoting mathematics have been done in the past and are still prevalent, but I think the mathematics community needs to move the campaign to the mathematics classroom.

Learning First Alliance previously suggested that U.S. schools cover too broad an area of subject material in its courses. Cutting back the amount of material covered will allow mathematics instructors (and students) the time to investigate (and realize) some "real world" applications of the mathematics they are required to study. I believe applicability of mathematics should be involved at every level of education, but unfortunately it is not always a feasible option for the teachers.

Commitment, Work Ethic

"I find if it (mathematics) is explained to me well, I learn it and can easily do it. But if I don't understand it when I leave class, it is a lost hope. It is pointless for me to try to learn it." The last sentence of this quote may tell the story for many students who struggle with learning mathematics. Many endeavors in one's lifetime are difficult and challenging; mathematics is on this list for many students.

There is a multitude of ways to overcome adversity. One possible path is to strengthen

one's commitment to perform the task(s) involved. Assessing one's self efficacy during one's educational career might identify erroneous perceptions and allow for appropriate interventions (Pajares & Miller, 1994). This would suggest that reevaluation of self-efficacy be a continuous process throughout one's educational lifetime.

If one's commitment to the task at hand is heartfelt and enduring, it can provide many benefits to the individual. It is my opinion that with commitment and patience comes competence and self-worth (confidence). With increased levels of confidence and competence, the learning of mathematics (or any other subject matter) will likely follow. Mathematics teachers need to realize that many students have feelings of incompetence toward mathematics and show empathy to those affected while working to reconstruct their psyches.

Some students' difficulties with mathematics stem from their sources of conviction (Szydlik, 2000). Ho et al. (2000) discovered that persistence rather than ability could account for differences in mathematical performance. One student had this response when discussing mathematics: "I don't really like or dislike math. To me, its just something that I have to do." This could be construed either positively or negatively.

There is no guarantee that one will "like" everything one does in one's lifetime. I choose to look at the student's previous comment positively. If one approaches tasks that "have to be done" with a solid work ethic and the commitment to do "whatever it takes" to "get through" the necessary requirements, almost any task, within human reason, can be completed. I cannot say it any better than the respondent, who replied,

> "I really started enjoying Math, here in this class. I feel I have a pretty good comprehension of what is going on, and everyone is willing to help. In high school I didn't try very hard and regret that, but now I am faced with decisions that will affect my life here in college. Actually putting forth effort here in college math has made it an enjoyable experience."

An alter ego of commitment may be idleness or laziness. Dependence upon a calculator was stated by many respondents. Having difficulties with and feeling frustrated by fractions was also mentioned in student responses. A few are presented here.

> "Ever since I can remember I have struggled in Math class. The only math I seemed to get was Stats. I AM NOT GOOD W/Numbers and I can't live w/o my calculator."

> " I don't feel there is an important factor in learning mathematics! We have calculators so why waste good time, for example when in life are you going to write out a problem @ home when you have a calculator handy!? (When its not for a grade?)"

> "In early Elementary, teachers teach you to do math without calculators. Then from then on they let you use calculators. When that happens you forget how to do long hand division, fractions and all the other stuff."

Learning is not about speed, it is about deep-seeded understanding. It is a shame, when one loses these skills, one loses what I believe should be inherent, innate knowledge. I agree with the last respondent's comments. I fear that calculator usage turns many students into idle participants instead of active participants in thinking processes. Calculator usage possibly creates a desire for instantaneous gratification in students. The capabilities of technology should be interwoven in the curriculum, but I disagree with replacing the fundamentals (e.g., adding, fractions, multiplying, square roots, etc.) through the usage of calculators. Use them to enhance, not as a staple. Mathematics can be viewed as mental exercise, and, I believe, with extensive usage of the calculator, a sharpness of the mind deteriorates. It is my opinion that to get to higher levels of thinking, the basics of a subject should be automated.

SUMMARY

When qualitatively analyzing the five open-response questions, conclusions (themes, categories, and assertions) were formed because similar responses prevailed in more than one question (e.g., teacher influence may have appeared in responses for open-response question numbers one, three, four, and five).

Through the qualitative analysis, it became evident that irreparable damage (or everlasting interest) can be caused by teachers when it comes to attitudes and outlooks regarding mathematics. An inviting personality and quality presentations of material are characteristics of mathematics teachers that students seem to value; I agree. Young (1906) believed in the beauty

of mathematics and thought the responsibility of spreading this message belongs to the teachers of mathematics, I tend to agree. Students (especially ones who are averse to mathematics) need to see that teachers enjoy their jobs and have fun instructing. Through the students' responses, it is evident that they attach themselves to the attitude and mannerisms of the instructor. Enthusiasm and energy are contagious. Getting into the minds of the students and changing perceptions and stereotypes regarding mathematics (and their own abilities to do mathematics) would be a step in the right direction. Students need to witness and be told about the beauties of mathematics (even if they do not believe). If told with the "right" delivery (not too seriously and not too haphazardly) and often enough, the students might start to believe. I also believe that students need to realize that being "wrong" is acceptable and actually a part of mathematics. Through errors, answers might become available. Everybody makes errors (even those with a PhD); students with an apprehension toward mathematics should be made aware that all have their troubles with mathematics. How one chooses to deal with adversity and challenges is one factor in determining what separates individuals.

Many different learning styles are represented throughout the data and vary among respondents. People think differently; this is a given. But, everybody has the characteristic of self-confidence (albeit in varying levels). Students' beliefs and attitudes about mathematics may inhibit their understanding in the domain of mathematics learning (Williams, 1991). It may be time to stress the teaching of philosophical and psychological approaches to enhance cognitive strategies to learning for students struggling with mathematics. By this, I mean that the teaching of mathematical concepts is not the toughest part of teaching mathematics. In my years of teaching mathematics, to a wide variety of students, helping a student overcome one's feelings of ineptness and inadequacies toward mathematics has been the bigger challenge. My experiences with mathematics students have shown that believing in oneself and one's abilities have proven to be the biggest factors in performing mathematical computations. So, I say elevate a student's

level of self-confidence (possibly through positive reinforcement) and the learning of mathematics will likely follow.

Students are hungry for the integration of mathematics and want to know how mathematics can help them (Wilson, 2000). It is up to instructors of mathematics to teach them how it is integrated into everyday life. When students think that the basics of adding, subtracting, multiplying, and dividing are adequate to exist in society, in my opinion, they do a disservice to the great minds of the past and present that helped the evolution of mankind along. They are taking the existence of all the modern day "luxuries" for granted. The application of mathematics is involved in most everything. Maybe students need to see more "hard" evidence (e.g., the computer programs) to have a greater appreciation for the immense contributions made from the field of mathematics.

The path to mathematical success is much like that of any other: work hard, learn from one's mistakes, and be persistent and confident. A key here is persistence; mathematics, in particular, lends itself to constant study rather than occasional cramming. Students should not let an isolated (or more than one) bad experience or teacher(s) in mathematics dictate their future success in mathematics. Just as teachers should not prejudge students by past performance, students should not prejudge mathematics from past experiences. In my opinion, a person's attitude toward learning mathematics is everything and each dawn is a new day.

Mathematics is created through human activity. Since humans created mathematics, they must have access to the ways of knowing its solutions. What individuals see, understand, and learn is constrained and afforded by what they currently know. Mathematical learning is therefore a process of the transformation of one's knowing and ways of acting (Simon et al., 2000). By using the term transformation, Simon et al. mean to indicate that learning involves a modification of existing ideas, not just the accumulation of additional ideas. This is a key statement here; mathematics is not memorization and regurgitation, but recognition of the

problem, utilization of the processes, and verification of results. I believe learning mathematics is about one's approach to the unknown and the unlearned. It is about how one faces and responds to challenges in any aspect of one's life. Mathematics, as well as the life process, is not absolute. Both are not about their ends, eventual death for one, a correct answer (sometimes the answer is there is no answer) for the other. The means by which one reaches one's end, trial and error, paths chosen and paths not chosen, are what turn out to be the important pieces involved in each puzzle.

RECOMMENDATIONS

Some respondents were quoted as having liked mathematics only to have a bad experience turn their like into a dislike of mathematics. If students can go from liking mathematics to disliking mathematics, it should be possible to get them back from disliking mathematics to again liking mathematics. Research could take the form of case studies or ethnography to explore what turned students away from mathematics, and what it would take to get them to enjoy mathematics again (or at least not have a feeling of disdain toward mathematics).

Some respondents really liked mathematics but did not like geometry. A case in point is one respondent quoted as saying,

> "Whether you like math or not is a broad question. I hate Geometry but love Algebra I basically began to like Algebra in 8th grade when it came to me naturally. I hated Geometry, shapes aren't my thing. Algebra II (my Junior year) was my best math experience because that's when I realized I was really good at it."

Maybe the mathematics community needs to look at how geometry is taught and the curriculum covered at the middle school and high school levels. Do two-column proofs (why not proofs written in paragraph form?) have to be stressed in ninth or tenth grade geometry?

Assertions from Qualitatative Analysis

Assertion 1: If a student likes the teacher, the student will want to perform well in the course. If a student likes the subject matter, the performance of the teacher is not a big factor. It may come down to intrinsic versus extrinsic motivation, with extrinsic value possibly being more

important in the way that it can enhance intrinsic motivation.

Assertion 2: Teaching mathematics to the non-math, non-science major is not so much about the mathematical knowledge of the instructor, but more so about their passion toward teaching mathematics, personality, and commitment to the student.

Assertion 3: Students want to see how mathematics applies to everyday life. Doing so may prove to be difficult, but more has to be done in this area. Giving students examples that apply to their specific major will help eliminate the recurring student question, "Where am I ever going to use mathematics?"

Assertion 4: Aiken and Dreger's Mathematics Attitude Scale (Aiken, 1996) may not be as good a predictor of feelings toward mathematics as a qualitative open-response survey. According to the dispersement of respondents with high Mathematics Attitude Scale scores disliking mathematics and low Mathematics Attitude Scale scores liking mathematics, the data may suggest that a better assessment would be to give open response questions.

Assertion 5: Students need the opportunity to write about and express their frustrations regarding mathematics. It can work as a form of therapy, an outlet for frustrations so they do not become bottled up and progressively strengthen into an irreparable condition. Giving the students an outlet to express their thoughts will let the students know an instructor values their input. After analyzing all the responses, it is apparent that students are quite astute in their observations. Having students put their thoughts to paper will possibly help improve student/teacher relations. Instructors have to be willing to listen to students' suggestions and adjust teaching styles and techniques accordingly. One student's response made the whole research project worthwhile.

> "Grade 4 - & every grade after. You are taught to learn to get thru the test, not thru life. No teacher every spends time teaching how to read a tape measure - how come? It is practical to learn younger the everyday stuff you need. Now Geometry is probably useful but tell me why & not just little examples get into it. Give us depth to remember. Engage us. Have us figure out a buildings structure - Not just triangles we need to apply the concepts. But most teachers couldn't apply them because they don't know how. And why not--- because they were never required to think so how can they engage us?
>
> These questions should be given to 5th graders they'll tell you why they hate math. And then to 7th

> graders what do you not feel comfortable with in Mathematics without their names being attached to it. I always said I understood because if I didn't everyone would think I was stupid - in reality none of us really understood why we had to learn
>
> What for? You told us everyone hates word problems. Which is true because we didn't get enough of them in grade school to make them easy. Repetition is everything in success. But we were always told that they won't be on the test - so you just "get thru them" for the homework.
>
> It is amazing you even ask the question - Teachers (from my experience) really don't want to know & don't care. They just have to cover material & don't be a whiner.
>
> Thanks for listening"

Possibly, the most important thing taken from this research may be the idea that instructors of mathematics (or any subject area for that matter) need to take student opinions into consideration when incorporating teaching strategies. Giving students a voice in the educational process seems paramount to their success. This does not mean students will dictate policy; but, if it does nothing else, at least it will work as a type of therapy for students in letting them vent their concerns and frustrations.

I will end with one student's comment concerning the learning of mathematics: "Math is easy if you practice it. It is not like riding a bike."

APPENDIX

Open-Response Questions

1. Have the teacher(s) you have had for mathematics had any effect on your fondness or dislike of mathematics? How so? (Please give as much detail as possible.)

2. Do you enjoy being challenged in some areas of your life? Please explain why these areas are areas where you enjoy being challenged.

3. What do you feel is the single most important factor in learning mathematics?

4. In your opinion, what makes mathematics difficult to understand or easy to understand?

5. If you find yourself liking or disliking mathematics, can you pinpoint where, when, and why the like or dislike started? Please give as much detail as possible regarding grade level, teacher(s) (styles, comments, etc.), subject matter (arithmetic, algebra, geometry, etc.). (Please use back of page if more room is needed.)

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