Developing the Underutilized Mathematical Strengths of Students

Patrick Eggleton (Taylor University)

Patrick Eggleton is an Associate Professor of Mathematics at Taylor University, where he teaches mathematics and prepares future mathematics teachers. He has taught mathematics at grade levels from elementary to the university, encouraging students to explore their ability to solve problems and develop logical solutions. From 2000 to 2004 he served as the President to the Indiana Council of Teachers of Mathematics. His primary interests are in instructional strategies and motivation.

Abstract

One of the continual challenges faced by mathematics educators is the predisposition of many students with an angst toward mathematics. One student wrote, "If I could describe my high school mathematics experience, I would describe it as my worst enemy gouging my eyes out with a silver spoon, while playing the high-pitched mosquito sound. In simpler terms, math in high school for me was absolute torture." (College freshman, February 2017) As Christian educators, we not only want such students to overcome their anxiety and dread toward mathematics, but we also want them to see its value to all aspects of their lives. "Indeed, we maintain that the study of mathematics is important for every educated person, and especially for a Christian. In fact, a good argument can be made that such study will not only make people more effective in their Christian calling; it will also enrich their lives in personal ways, and in ways that will make them more effective as they work to bring about peace, wholeness, and harmony in our world." [2, p. 246] To help students confront any negative predispositions that prevent their ability to actualize their full potential - which includes the thinking habits inherent in mathematics, we need an awareness of how mathematical dispositions are developed and what might have the greatest impact on reforming those dispositions so the student's full potential can be achieved. The following study shares influences related to mathematical disposition development and provides possible direction for educators who seek to mold this disposition so their students will be more effective in their Christian calling.

1 Background

The *Curriculum and Evaluation Standards for School Mathematics* emphasized the assessment of mathematical disposition as an essential element in the mathematical development of students. [6, p. 233] This document articulates an excellent description of a positive mathematical disposition (e.g. the student has confidence using mathematics to solve problems and the student is willing to persevere in mathematical tasks) and makes suggestions on how to assess this disposition, yet in practice, disposition is often considered a byproduct to our instructional attempts. The *Principles to Action: Ensuring Mathematical Success for All* [7] and the *Common Core State Standards for Mathematics* reiterate the importance of a "productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy)". [3, p. 6] Wilkerson adds that Christian mathematics educators have a responsibility to influence students' mathematical affections, "...not merely knowing, but also loving, and practicing the truth, beauty, and goodness inherent in mathematics." [10, p. 112] Research studies have developed a number of ways to assess student dispositions toward mathematics (often referred to as attitude toward mathematics). Zan and DiMartino [11]

used questionnaires and student essays titled "Me and mathematics: My relationship with maths up to now" to identify themes related to mathematical dispositions. They observed three primary themes related to disposition: (1) the emotional disposition toward mathematics (I like/dislike mathematics), (2) the perception of being/not being able to succeed in mathematics, and (3) the vision of mathematics (mathematics is . . .). While this study provided valuable themes associated with mathematical dispositions, the disposition remained a byproduct with the development of those dispositions primarily implied by the themes. Haladyna [4] used a self-reporting survey on attitude toward mathematics and inferred from those surveys the primary influences toward mathematical disposition as teacher quality and the social-psychological climate (assessed by responses to items such as "How much do you like the students in your class?" and "The students would be proud to show the classroom to a visitor.") While it seems plausible that teacher quality and the climate of the classroom would be influential in a student's emotional disposition, perception of success, and view of the nature of mathematics, these studies could benefit from some form of replication to validate or expand upon these findings.

2 Method

Students taking Investigations in Mathematics at Taylor University begin each semester with a required one-page essay entitled, "Mathematics in my Past and my Hope for the Future." Following the submission of their essays, students in the Spring 2017 classes were asked if they would allow their essays to be analyzed in order to identify constructs that influenced their mathematical disposition. (Approval of the use of human subjects was granted by the Taylor University Institutional Review Board in January 2017.) Seventy of the 75 students agreed. As essays were read, any information communicated that directly or indirectly related to the student's emotional disposition toward mathematics, perception of success, or vision of mathematics was cut from the text (including context as necessary) and arranged in a spreadsheet for further analysis. Over 200 quotes were identified (See Figure 1).

Example Quotes per Category

Teacher:
Because of certain teachers I had, I started to despise math and wanted to avoid it at all costs. (#7) Then during sixth grade, I had a teacher whose method of teaching just clicked with me for some reason, and after that I didn't hate math anymore. (#40)

Nature of Math:
The thought of spending hours just thinking about how to solve a problem, or trying unsuccessfully numerous times to do so has never been appealing to me, so I chose not to set myself up for that type of situation. (#19) During my senior year I took statistics, a senior level class. While this class was a walk in the park compared to my precalculus class, I really did enjoy it. I found a way to make it fun and to make it applicable to events that could arise in my future as an adult. I think this skill is valuable because if I get the idea in my mind that something is either boring or not useful, then I am less likely to be willing to learn it. (#25)

Success:
Mathematics has always been something that usually came naturally to me. Many times, when I would grasp a concept, I could start cranking out answers left and right. However, grasping the concepts would be something that frustrated me. If I couldn't quite figure out a solid answer, it would irritate me so much. (#35) I know for sure I will fail. Failing is not an option. (#63)

Figure 1: Examples of categorized quotes from the analysis.

The collected quotes were then reviewed several times in order to infer any general themes related to

influence within the descriptions of mathematical dispositions. Three categories of influence surfaced from this analysis: (1) mathematics teachers, (2) the perceived nature of mathematics, and (3) success or lack of success in prior classes. The quotes related to influence were then coded based on these categories (using a 4^{th} category of "other" for influences that did not fit one of these categories). At the end of the semester, students were given a brief survey (see Figure 2) where they were asked to rate their personal disposition of mathematics while also ranking the three categories that surfaced from the analysis of the data.

Thank you for helping with the research related to what has influenced your current disposition toward mathematics. To help finalize our results, would you please answer each of the following:
On a scale of 1 to 10, 1 being I dislike math to 10 being I like math, I would rate my disposition to mathematics as (circle one)
1 2 3 4 5 6 7 8 9 10
All of us have had influences in our life that affect our current dispositions. In looking through the reflection journals we generalized to 3 common influences on a person's disposition toward math: Teacher (either helping me to like or dislike math), the Nature of Math (from being useful and precise to being confusing and difficult), and Success (I was usually successful in math to I was usually not successful in math). Please rank these 3 influences based on how they have affected your disposition (my tendency to dislike or like) toward mathematics. (For instance, the following ranking would indicate that the teacher had the most influence, that Nature of Math had the second most influence, and my Success had the least influence on how I feel about math: 1 - Teacher, 2 - Nature of Math, 3 - Success)

Rank: 1st, 2nd, and 3rd
_____ Teacher
_____ Nature of Math
_____ Success

Figure 2: Self-assessment of mathematical disposition and ranking of influences related to it.

---

3 Results

Figure 3 shows the distribution of the influences as they were designated by our coding schema.

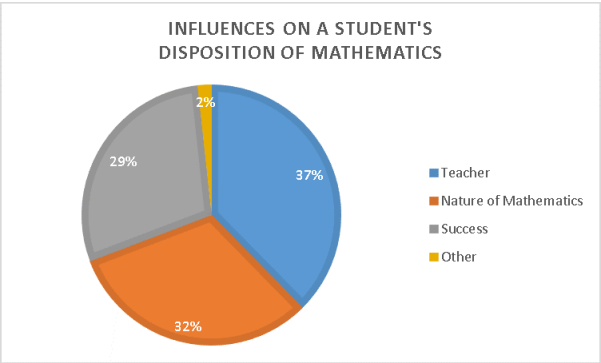

Figure 3: Distribution of influences on a student's disposition of mathematics as coded.

A Chi-Square goodness of fit test between the 3 primary categories indicated that our coding showed no significant differences between the categories (χ^2 = 1.27, p = .529). Of course, one student may have had more than one influence indicated in their essay or may have had several different quotes all related

to the same influence with each quote being counted separately. Allowing students the opportunity to rank these influences yielded slightly different results (see Figure 4).

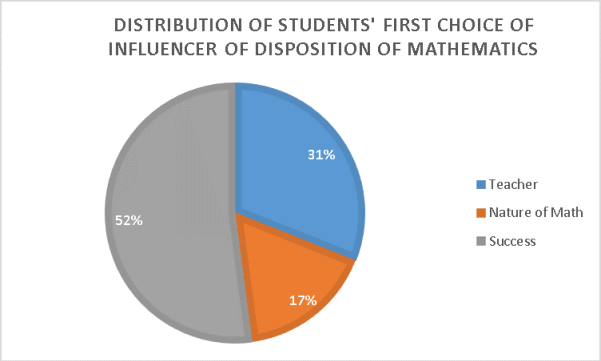

Figure 4: Distribution of students' first choice of influence on their disposition of mathematics.

These results did show significant differences between the categories ($\chi^2 = 13.4$, $p = 0.001$) with "Success" being the most significant influence on a student's disposition toward mathematics. Using the students' self-reported disposition level (1 being disliking math to 10 being liking math), "Success" or "Lack of Success" continued to dominate as the most significant influence to a student's mathematical disposition. (See Table 1). It is noted that students signifying a stronger disposition to mathematics did indicate the teacher as being more influential in developing that disposition.

		Influence		
		Teacher	Nature of Math	Success
Self-Reported Disposition Level	Lowest (1-3)	20%	30%	50%
	Highest (8-10)	39%	6%	56%

Table 1: Top ranking of influences to mathematical disposition compared to student's self-reported disposition.

4 Self-reported Disposition Level

While there are certainly concerns regarding subjectivity with the coding of the data and oversimplifying when eliciting the self-evaluations, the prevalence of the influential nature of a student's success and the influence of their mathematics teacher is significant for professional mathematics educators to note. Outcomes from other studies imply similar results. For instance, Hannula shared detailed observations of a case study, Rita. Initially Rita had a poor disposition toward mathematics. As she gained success or understanding, Rita's disposition improved. "How can we then explain this change? Why did it happen? What brought it about? Our first answer comes from Rita. Mathematics was 'more fun' because she had 'been understanding more.' In another interview she remarked that 'that must be the nicest thing exactly that one understands the topic.' " [5, p. 41] Wamsted's story of a breakfast conversation with his two children communicates a similar result. While his second grade daughter, Kira, deliberated over a mathematics problem that her father had suggested, her kindergarten brother cuts in with answers on two subsequent occasions. Following the second answer from her younger brother, Kira exclaims, "John is so much better at math than me." [8, p. 486] Wamsted further explains that Kira actually had an affinity for math and had been identified for the gifted and talented program in the district. While Wamsted attributes his concern for Kira to gender stereotypes, this episode also seems to communicate

how quickly the lack of success (especially when shown up by your younger brother) can contribute to a child's mathematical disposition.

There is also a surprising connection to the influence of progress and success shared by research in the business world. Amabile and Kramer's research on what motivates workers communicated counter-intuitive results to leaders in the business world. They provided a multiyear study tracking the day-to-day activities, emotions, and motivation levels of hundreds of knowledge workers in a variety of settings and found that the top motivating factor for workers was progress. "When workers sense they're making headway, their drive to succeed is at its peak." [1, p. 44] In contrast, the managers of these workers thought that making progress was one of the least important motivators to their workers, opting for incentives or working atmosphere as more important. Progress and its eventual product success (or lack of progress and eventual failure) is not only important to the disposition of workers in the business world, but it is also of significant value to workers in the classroom.

While the importance of making progress and developing success are influential factors for developing positive mathematical dispositions, the teacher and the nature of the mathematics that is taught are also essential factors, as noted by the student essays and their survey responses. Teachers who communicated that they cared about students or really enjoyed the content tended to have the most positive impact on mathematical disposition. Similarly, teachers who communicated indifference to the challenges students faced or promoted a dry routine of drill and practice tended to have a negative impact on mathematical disposition. The following student captured both of these influences:

In the past I have not enjoyed math class. That is not to say that I do not enjoy mathematics—I believe that I would if it had been taught to me in a different manner—but I have had very negative experiences with math in school. I believe that the root of this is, as I have already suggested, the utterly prosaic way in which mathematics seems to be traditionally presented and taught. It is presented as a thing onto itself, an existence which excludes connection to all other subjects (except, perhaps, science) and only seeks to serve the practical. It had seemed far removed from the world of the imagination that I cherish and, for that matter, from the world [of] logic and thinking. This, of course, is a vast misperception. Nevertheless, this is the vague and misconstrued form of mathematics that my teachers (unknowingly) presented to me. Equations were learned by memorization, without reference to the natural world from which they were derived, and problems solved by the simple method of plugging in a number to an equation and following through on the taught steps to find the answer. To me, the pursuit seemed purposeless. (Student #54)

5 Conclusions

"God created us with a capacity to do mathematics, so using that capacity must be part of God's will for us." [2, p. 11] One of the greatest frustrations we face as Christian mathematics educators is when we work with students who fail to recognize the influence that mathematics can have on their vocation. Mathematics develops important thinking habits of all sorts: "analyzing carefully the implications of one's statements, being careful with the meanings of words, imagining alternative interpretations or possibilities for action, and recognizing that the mere declaration of your opinion on an issue does not render it true." [2, p. 248] Regardless of an individual's calling, these mathematical habits will improve the quality of participation within that vocation. To benefit from the study of mathematics, students need a disposition toward mathematics that will motivate them to value their God-given capacity for the subject. As shared by the students in this study, the teacher plays a significant role in developing a student's disposition toward mathematics either positively or negatively. To promote positive dispo-

sitions of mathematics, teachers must accept the responsibility for the important role that they play. One tool teachers need to use in developing a positive disposition toward mathematics is the use of progress to develop success. Students who don't feel they are making progress can quickly succumb to a poor disposition toward their work. Adolescence is a turbulent time when attitudes can quickly derail due to the challenges of learning. Our classrooms need to promote progress that leads to genuine success so that students will develop the ability and determination to persevere through the rigors of their studies to maximize their potential. When progress and success seem to be insurmountable goals, teachers need to break down the tasks and concepts in order to make progress and success attainable once again. Teachers can also provide opportunities to explore various facets of mathematics, helping students reflect upon the beauty and "unreasonable effectiveness" [9] with which this language communicates about creation. Scripture shares that we should exercise whatever abilities God has given us "with all the strength and energy that God supplies so that God will be glorified through Jesus Christ." (1 Peter 4: 11 TLB) As Christian mathematics educators, we make it our goal to do what is needed so that the underutilized mathematical strength of many students will be better utilized in their vocations and ultimately in glorifying God.

References

[1] Amabile T. M., and Kramer S.J. 2010. "What really motivates workers". *Harvard Business Review.* 88 (1-2): 1-2.

[2] Howell, Russell W., and James Bradley. 2011. *Mathematics through the eyes of faith*. New York: HarperOne.

[3] Common Core State Standards Initiative. 2011. *Common Core State Standards for Mathematics*.

[4] Haladyna, Tom. 1983. "A Causal Analysis of Attitude toward Mathematics". *Journal for Research in Mathematics Education.* 14 (1) 19-29.

[5] Hannula, Markku S. 2002. "Attitude towards mathematics: emotions, expectations and values". *Educational Studies in Mathematics: An International Journal*. 49 (1) 25-46.

[6] National Council of Teachers of Mathematics 1989. *Curriculum and evaluation standards for school mathematics*. Reston, Va: The Council.

[7] National Council of Teachers of Mathematics. 2014. *Principles to actions: ensuring mathematical success for all*.

[8] Wamsted, John. 2017. "Sound Off! Better at Math Than Me": Questions about Equity, from the "Kitchen Table to the Classroom". *Mathematics Teacher*. 110 (7) 486-486.

[9] Wigner, Eugene. 1960. "The unreasonable effectiveness of mathematics in the natural sciences". *Communications in Pure and Applied Mathematics*. 13 (1) 9.

[10] Wilkerson J. 2015. "Cultivating Mathematical Affections: The Influence of Christian Faith on Mathematics Pedagogy". *Perspectives On Science and Christian Faith*. 67 (2) 111-123.

[11] Zan, Rosetta and Pietro Di Martino. "Attitude toward mathematics: Overcoming the positive/negative dichotomy". In Torner, Gunter, and Bharath Sriraman. 2008. *Beliefs and mathematics: Festschrift in honor of Gunter Torner's 60th birthday*. Charlotte, NC: Information Age.