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Motivation in the Mathematics Classroom

An Undergraduate Honors Thesis
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by

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Abstract

Mathematics has always seemed to be an unpopular subject amongst primary and secondary students in the United States. This project seeks to identify the roots of these attitudes and examine them in ways that allow for personal reflection, community building, and student advocacy. An individual's access to educational resources and equitable treatment play a large role in shaping their mathematics learning identity. This topic was examined via traditional research methods for the written paper portion and also includes a set of lesson plans for teachers to use. These lesson plans utilize the ideas discussed in the paper portion to provide students a platform to examine how they can best learn mathematics. The lessons were also developed with few material demands to increase access for teachers.

Key words: math, teaching, motivation, identity, equity

Motivation in the Mathematics Classroom

Reading, writing, and arithmetic are the three pillars of a primary and secondary school's coursework, at least that is what I have heard my grandmother say about her own experience in school. My own experiences in the world of K-12 education included many other subjects besides the three R's, such as history, foreign language, and science. I am grateful to have learned in classrooms unlike the monotonous and infamous history class showcased in Ferris Bueller's Day Off, where a bland teacher drones on about historical dates while students fall asleep and disengage at every level. The mathematics learning experience of each generation is changing as educators continue to embrace new approaches to teaching the subject (Boaler, 2015). The prior focus on the "R" of arithmetic is a misnomer for mathematics. Merriam-Webster defines arithmetic as "a branch of mathematics that deals with nonnegative real numbers and the applications of basic operations to them" (2020). My own high school mathematics learning experience was defined by big group projects and independent presentations that stressed the skills of collaboration and communication alongside the content.

Another peculiar pattern I started to notice among my high school peers were repeated claims that mathematics class was "pointless" as it stressed "skills that would not be used outside of the classroom." This mistake of viewing arithmetic as a perfect stand-in for all of mathematics returns, so what else is leading students to have a negative perception of learning mathematics? According to the National Council of Teachers of Mathematics (NCTM), "only sixteen percent of U.S. high school seniors are proficient in mathematics and interested in a STEM career" (NCTM, 2014, p.2). This chilling statistic highlights that our education system is not effectively teaching students to do or be interested in mathematics. What opportunities are not being taken or do not exist for our students to engage in learning mathematics more effectively?

Purpose of this Paper

In a mathematics classroom that provides opportunities for students to be successful students are challenged to communicate, collaborate, and think creatively on a daily basis. Throughout this paper, I will examine what mathematics instruction is like today as well as how to serve every student no matter their initial level of interest in learning this subject. After an analysis of how to further enhance the learning of mathematics, I present a set of lesson plans that have been designed to focus student thinking on how they can best identify their own interest in mathematics and utilize it outside of the classroom.

Mathematics Classrooms in the 21st Century

When I step in front of a classroom of teenage students, the first thing I do without hesitation is ask them to put their phones away. According to Versel (2018), “eighty-two percent of high school students in the United States regularly use a smartphone” (para 5). Such common access to technology has allowed this generation of students countless new ways to learn. Some of my own professors share stories of a time before graphing calculators when students were required to use a book of calculations in order to complete problems on their exams in time. The technological savviness of this generation of students is not their only notable characteristic. Today’s high school students are more accepting of their peers than their predecessors (Twenge, 2017). This heightened sense of the wider community’s needs is a wonderful addition to every classroom, but sadly does not end all problems for our nation’s educators. While this generation is more apt to accept one another, the same cannot be said for the teachers and students in classrooms and schools across the country. Luckily, it does provide teachers with a new platform to gather knowledge of their students and better serve them. If students are more attuned to one another, then teachers can utilize this communal student feedback about classroom perceptions

and concerns more frequently. Teachers can use this feedback to adapt instruction as it will do a better job than in years prior in reflecting the classroom communities needs over personal ones.

Another characteristic of current K-12 students is their ability to recognize differences in their peers' experiences; this increased awareness of issues around them has led students to become more stressed and critical about the world they live in (Twenge, 2017). This stress can easily disrupt student learning if teachers allow students to dwell on the intense pressures they are experiencing. However, modern high school students are showing they are willing to advocate. While social media challenges and internet petitions provide a few simple avenues to claim the title of advocate, school provides a different opportunity to engage in advocacy. Our students may be quick to identify a problem, but they are rarely presented a time and place to come up with their own solutions. This makes school and especially the mathematics classroom a perfect environment to challenge students to explore new ways to advocate for change.

Interest and Proficiency in Mathematics

As previously stated, sixteen percent of American high school seniors are both interested in and proficient in math (NCTM, 2014). This truth shows us the reality of the poor perception students have of mathematics and the learning of it. There exist a few different possibilities for why students might lack interest in the STEM field. These possibilities include having other academic or professional interests, having a negative mathematics learning experience, and developing a negative perception from others' experiences. I describe each of these possibilities below and provide recommendations for what teachers might attempt to do in order to mitigate this poor perception.

Interest and Experiences in STEM and Non-STEM Fields

Students might be more interested and invested in other fields of study/lines of work or they may have had a negative experience learning mathematics. Student interest in any subject is sure to boost engagement if teachers can draw realistic connections to mathematics. Aguirre et al. (2013) showcase such a case when a high school student reflects on how her passion for music is connected to mathematics through the use of fractions and statistics. Providing a thorough explanation of what mathematics actually is to students is critical to counteract the misconceptions about it being strictly arithmetic. If there is a student that communicates their legitimate interest in arithmetic or any other smaller branch of mathematics, continue to build connections from these interests to other branches of mathematics. Just as history teachers might continuously make connections between different historical events and regions of the world, mathematics teachers ought to do the same with mathematical concepts (NCTM, 2014).

For students who have experienced learning mathematics in a negative light, it is important to remind them they are active participants in their learning (Aguirre et al., 2013). By doing this, students are not only reclaiming their own agency as a learner of mathematics, but also gaining a deeper understanding of how the external factors in the learning process are helping or hindering them.

Developing Negative Perceptions from Others

Another factor that could affect student interest in mathematics is inheriting some negative perceptions about learning mathematics from a family member or friend. Keep in mind that negative perceptions about learning math could take the form of inheriting a label of being a “fast” math student. Language holds a lot of power over how we feel about our identity and being given a label such as “fast” when you might not associate with it can create a negative

learning experience (Aguirre et al., 2013). While it is understood that successful learning of mathematics does not entail doing computations as quickly as possible, projecting your own perceived mathematical strengths onto others is dangerous. It is much more beneficial for the larger community of learners to affirm the strengths of others just as you do with your own. Recognizing community assets is key to equity-based teaching practices (Aguirre et al., 2013). This means continuously assessing how each of your students contributes to the larger class or even school. Shifting the focus of assessment to student assets over student deficits is helpful in reinforcing positive mathematical learning identities. It is also beneficial to avoid reinforcing negative titles that students may have been given in the past from the school such as “remedial” or “slow” math students. Instead of reinforcing these labels challenge the students to analyze how these labels have helped or hindered them in their productive math learning or other life experiences.

Identity Development as a Vehicle for Improving Interest and Perceptions

In the above sections I describe some of the factors related to students’ varying interests and perceptions about mathematics. In this section, I address the problem of supporting students to learn about their own identity in the context of being a mathematics student since how one identifies is a critical element in how they experience mathematics and the world around them. In order to answer this question let’s examine a hypothetical mathematics student. Our hypothetical student is not interested in the STEM field but does extremely well on standardized assessments. This situation may sound out of the ordinary but can show us a lot about access, achievement, and advancement.

First off, this student is not interested in working in the world of mathematics but does well on mathematics assessments. This leads us to consider the following: how well do

standardized assessments measure student understanding and how well is this student's mathematics teacher drawing connections from other interests to mathematics? High proficiency learners such as this hypothetical student are likely to see a higher frequency of positive reinforcement from the school whether that be directly from a teacher or administrator or even how their assessments are given. For example, if all the exam problems are written in a language that the student can easily understand without having to reread it you will be able to focus more time on showcasing your mathematical abilities instead of taking two tests, one on language comprehension and then another in math. Also, if we consider that this hypothetical student's mathematics teacher struggles in creating connections to class concepts for their classes, we will see this student adopt some unproductive beliefs about the subject. One such unproductive belief as shared by NCTM (2014) is that students ought to "memorize information that is presented and then use it to solve routine problems on tests" (p. 11). It is quite possible that this student has adopted this belief as investing in solving routine problems could lead to success on some standardized assessments.

This observation also emphasizes the need to consider how well standardized tests can measure student understanding. While procedural fluency is critical to student success in the mathematics classroom it is only one part of building a student's thorough understanding of doing mathematics. Another type of assessment that students may have interacted with is the "math minute" quizzes often used in elementary school classrooms. These tests put the focus on speed and memorization. While these types of assessments are used to establish and build a student's foundation in number facts, the perception from students are quite different. From the student perspective, success is solely measured by your ability to answer more questions than

your peers. From an educator's perspective, these assessments do provide important insight about the foundational knowledge of the students in a particular class.

The disconnect between the teacher and student perspectives can be explained by the lack of communication and inattention to equity. Aguirre et al. (2013) says that "equity does not mean that every student receives identical instruction" (p. 9). By not effectively communicating the reasoning for classroom actions to the students we are not only providing students a warped view of their learning experience, but we are also robbing them of the opportunity to advocate for more equitable experiences. Moses and Cobb Jr. (2001), share that equitable teaching "matched how I believed in teaching - having a conversation" (p. 123). This focus on promoting equity through discussion is the basis for the lessons at the end of this document. By posing questions to students and allowing questions to be posed to you as a teacher of mathematics, students can examine how their own mathematics learning identity is evolving as a student in your classroom.

Recommendations

In order to best support students in gaining a fuller understanding of how they best learn mathematics it is critical to allow for constant change. For our hypothetical student to learn it is the responsibility of the teacher to allow students to discover how different experiences and identity impact their learning. The struggles students experience can take on many different appearances. As previously discussed, students may not have equitable access to adequate learning resources. Students rarely have similar levels of access to materials such as quality textbooks, manipulatives, technology, and daily classroom supplies (Moses & Cobb Jr., 2001). The differences in access may be more noticeable when comparing different state education systems, but access to resources can still differ across a single school district.

Providing learners with opportunities to consider their own circumstances may better prepare them to advocate for themselves in their future. Since we want our students to be effective advocates for themselves and others, it is imperative they feel supported when developing these skills. Teachers can do this by challenging students to consider how their attitudes towards learning math have changed over time. Asking questions such as “how did you feel about learning math in kindergarten compared to today,” can get students to consider how their own experience has changed over time. Understanding past changes allow for future change to happen and become more effective (Moses & Cobb Jr., 2001). If our students are to create meaningful change, they need to become familiar with how the issue has been confronted in the past. For example, according to the National Academies Press (2012) “more than half of students who intend to major in a science or engineering field switch to a different major in college,” (p. 19). By understanding how successful college student retention in STEM programs was in 2012 compared to now we can better advocate for change. Building up primary and secondary students’ advocacy abilities is beneficial for the entire world of mathematics learning, as an increase in student voice will help teachers adopt equitable teaching practices.

In order to properly guide students towards reflecting on their own math learning identities, it is important to grant them agency in asking questions about what might have impacted the shaping of their identity. While it can be uncomfortable to yield control of the classroom to students, allowing them to examine your classroom as a place that can help and hinder them in different capacities will allow them to discover a new way to invest in their learning. Once students can better understand their own needs in the classroom, they will not only be more capable students, but leaders and advocates as well.

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Lesson Design Explanations

I designed the lessons, which can be found at the end of this document, to act as a guide for teachers to utilize to address the factors presented earlier from the research around student interest, proficiency, and identity development. When developing these lessons, the values of easy access and utilization were at the forefront of planning. This means the lessons should be able to be used by any teacher that wants to use them regardless of access to materials/technology. There are three separate lessons that should be taught in order, but they do not need to be taught back-to-back as I realize that teachers might not have the opportunity to fit in all three in the same day/week. Each lesson is intended to take approximately forty minutes for a total of two hours.

The Impact of COVID-19

The original plans for this project have been drastically changed by the outbreak of COVID-19 and the closure of public schools in Lincoln, NE. While the final product of this project has been evolving over the last year, prior to school closures, I intended to teach the following lessons in my student teaching experience as a way to pilot and assess the impact of the ideas explored in the paper portion of the project. However, since my student teaching placement ended early to allow for social distancing, I was not able to teach these lessons even in an online format. The following lesson plans are available to be used by any interested parties and hopefully both students and teachers benefit from using them.

Lessons Overview

As a set of three lessons, they work to address students' important role in shaping their learning experiences by giving them opportunities to learn about their own learning experiences and allow them a platform to advocate for beneficial changes. I describe each lesson in further detail below.

Lesson 1

Lesson 1 focuses on personal reflection and development of one's mathematics learning identity. I utilized ideas from Aguirre et al.'s (2013) work on the role identity plays in the learning of mathematics. The questions used in the reflection portion of this lesson were designed to get students to identify and analyze some preconceptions they have about mathematics and begin to draw connections to how their identity is affected. This lesson also allows students to analyze the factors that have contributed to their current feelings about the subject of mathematics.

Lesson 2

Lesson 2 focuses on building a community of learners through discussion of the strengths and needs of the different learners in the room. This attempts to establish a greater group identity of learners in the classroom, something Twenge (2017) hints at as a strength of students in today's classrooms. It also provides support for students to begin to learn how they can create solutions to problems they have identified through collaboration.

Lesson 3

Lesson 3 focuses on students advocating for change. This grants students a platform to utilize the knowledge they have gained in the previous lessons and use it to practice their

leadership skills to advocate for positive change. It also acts as a model for students to use in a mathematics classroom to continue to discuss their evolving learning needs with their teachers.

Lesson #1: Reflection on Personal Mathematics Learning Identity

Objectives:

- Students will know the different aspects of their mathematics learning identity.
- Students will understand how their math learning identity impacts their motivation.
- Students will be able to connect their learning experiences to different parts of their math learning identity.

Opening Activity: (15 minutes)

- Preface this lesson with a brief overview of this lesson's objectives and clarify the importance of effort over speed, as those who reflect thoughtfully will get the most out of the activity.
- Next, ask your students to all gather in the middle of the classroom.
- Once all your students are gathered, turn your back to them and tell them you will not know how they responded to any of the questions for the warmup.
- Tell them: "For this warmup please move to the side of the classroom that corresponds to how you feel about each statement I say. The left side of the classroom will strongly agree, and the right side of the classroom will strongly disagree. You can be anywhere between the two and remember I will not be turning around for this portion of the exercise. Please be quiet during this activity and look around at how the class responds to the prompts. What questions or concerns do you have about the warmup?"
- Answer any clarifying questions before you begin.
- "The first statement is: I love doing math. You may now move to reflect your feelings about this statement."

- Allow students a minute to organize themselves and make visual observations.
- “Please take 10 more seconds to look around at how others feel about the first statement.
The second statement is: I am good at doing math. You may now move to reflect your feelings about this statement.”
- Allow students a minute to organize themselves and make visual observations.
- “Please take 10 more seconds to look around at how others feel about the second statement. The third statement is: I enjoy coming to this class. You may now move to reflect your feelings about this statement.”
- Allow students a minute to organize themselves and make visual observations.
- “Please take 10 more seconds to look around at how others feel about the third statement.
The fourth statement is: I think learning math is helpful to my future success. You may now move to reflect your feelings about this statement.”
- Allow students a minute to organize themselves and make visual observations.
- “Please take 10 more seconds to look around at how others feel about the fourth statement. The final statement is: I reacted to the previous statements as honestly as possible. You may now move to reflect your feelings about this statement.”
- Allow students a minute to organize themselves and make visual observations.
- “Please take 10 more seconds to look around at how others feel about the final statement, then take your seats. I will be turning around in one minute.”
- Once everyone has seated themselves, distribute some lined paper and pencils.
- Ask your class: “Would anyone like to share what they learned from the warmup?”
- Allow your students about 5 minutes to process and share takeaways from the warmup as a class.

Reflection Activity: (20 minutes)

- As student discussion comes to a close, explain they will now have time to write a personal reflection on the following prompts. Stress that it is not required to respond to the prompts in the order they are given, but they should do their best to answer each thoroughly.
- The prompts are:
 - Who are you? (introduce yourself in a paragraph)
 - What has learning math been like for you in school?
 - What do you think learning math can and cannot include?
 - What are your future aspirations? How does math connect to them?
 - How do you feel when you are in school? How do you think your peers feel when they are in school?
 - When do you see math outside of math class? Where and how does it show up?
- Ask students to help create a focused writing atmosphere for their peers by focusing on their own writing.
- Answer student questions and concerns as needed. Remind students that they should be thoughtful in their responses.
- When 15 minutes have passed, tell the class that they should work to a good stopping point in the next 5 minutes. They do not need to be completely finished.

Closure Activity: (5 minutes)

- As students wrap up their personal written reflections begin to distribute one sticky note to each student.
- Once everyone has reached a good stopping point in their written reflections, ask students to write down one thing they enjoyed about the lesson and one thing they would've changed.
- Have students put their completed sticky notes at the front of the room and begin preparing for dismissal from class.
- Ask students to review and add to their reflections as homework and bring them to class the next day to hand in.

Lesson #2: Establishing a Community of Learners

Objectives:

- Students will know more about the members of their community of learners.
- Students will understand how their math learning identity contributes to the learning of their peers.
- Students will be able to identify the learning needs of their community.

Opening Activity: (10 minutes)

- Pass back students' written reflections they completed in lesson #1.
- Have students spend a couple of minutes silently reviewing their thoughts and feelings in their reflection.
- Next, ask students to stand up with their reflections and do a stand up, hand up, pair up. Let them know they will only have thirty seconds to share their thinking so they should do their best to be as concise as possible.
- Once students find a partner to talk to, have them talk about one of the following prompts for one minute (thirty seconds for each partner). Have students find a new partner for each prompt.
 - What has learning math been like for you in school?
 - What do you think learning math can and cannot include?
 - What are your future aspirations? How does math connect to them?
 - How do you feel when you are in school? How do you think your peers feel when they are in school?
- Once all prompts have been discussed have students take their seats.

Team Activity: (25 minutes)

- Group your class into teams of four (a few groups of three or five is also okay).
- Have teams talk about what they heard from their peers and shared during the warm up activity while you distribute writing materials and paper.
- Once materials are distributed, tell students that their teams will be developing a set of “laws” for their teams that promote good learning for everyone in the class.
- Remind them that their personal reflections and ideas they heard during the warmup will be critical to developing a satisfactory final product.
- Also, share that their set of “laws” should reflect the following expectations for all members of the class:
 - Beneficial student actions
 - Beneficial teacher actions
 - Support systems that can be utilized in class
 - Support systems that can be utilized outside of class
 - Avenues to amend the current set of rules
- Answer any questions or concerns about the explanation of the activity.
- Allow student teams 15 minutes to develop their set of “laws.”
- After 15 minutes, communicate that teams have 5 more minutes to get their final set of “laws” ready to submit.

Closure Activity: (5 minutes)

- Once you collect all final “laws” from the student teams, distribute sticky notes.

- Have each student write down:
 - 1 thing that their team did well
 - 1 thing they would do differently as a team during this activity
 - 1 unique strength they brought to their team
- Ask students to turn in their sticky notes to you before preparing for dismissal.

Lesson #3: Advocating for Change

Objectives:

- Students will know how well the current classroom environment supports their learning of mathematics.
- Students will understand how they can advocate for themselves.
- Students will be able to communicate possible paths of action to create positive change in their learning environment.

Opening Activity: (10 minutes)

- Group students into groups of three to five students.
- Distribute the sets of “laws” developed in lesson #2 randomly to the groups.
- Ask each team to review the set of “laws” given to them and propose up to three additions to the list. Their additions should seek to maximize the different types of learners in the classroom.
- Provide each team a minute to share their additions to the class.

Whole Group Activity: (25 minutes)

- Explain to the class that you have received a new set of classroom expectations and wanted to get their opinions on them.
- Each corner of the room hang a paper with one of the following topics:
 - Teacher actions
 - Student actions
 - In-school supports

- Out-of-school supports
- Under each topic, brainstorm and write a few “laws” that do not serve all the students.
- Let the students know they will have 10 minutes to brainstorm as an entire class all the additions they want to make to the existing “laws.” Remind them they do not all have to write on every paper. It is up to them what they would like to advocate for.
- Answer any questions or concerns students may have about instructions.
- Check in every few minutes of the exercise and remind students of the time remaining so they can go to a different topic if they would like.
- After the time has passed, ask students to take their seats.
- Once everyone has taken their seats, collect the additions they have proposed and begin asking for them to explain why this addition is beneficial for the community. Do this for as many as possible and try to group similar ideas together and get as much input from different students as possible.

Closure Activity: (5 minutes)

- Distribute sticky notes.
- Ask students to write down:
 - 1 thing they liked about the additions they suggested
 - 1 thing that made advocating difficult
 - 1 new idea they have about learning mathematics
- Collect completed student sticky notes and get class ready for dismissal.