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Increasing Opportunities for Students in Mathematics

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Abstract

We must examine our existing practices and policies in order to determine what changes should be made to increase opportunities for all students in mathematics. The world around us is changing, yet too often mathematics education has not changed in order to better meet the needs of our students and to better prepare them to be a productive global citizen.

Keywords: use of technology, relevance of content, mathematical identities, instructional pedagogy

THE NEED FOR CHANGE IN MATHEMATICS EDUCATION

Change must occur in mathematics education in order to continually increase opportunities for all students. Too many times and for too long, we have seen that not every student experiences success in mathematics. These learning experiences change how students see themselves, their mathematical and scholarly abilities, and their opportunities. We must make the necessary changes to improve mathematics education to meet the needs of today's students and modern society rather than that of a generation or two (or longer) ago.

For far too many students, they don't see the relevance and usefulness of what they are learning in mathematics. Students often view mathematics as a series of disconnected procedures that must be memorized and followed in order to calculate the correct answer. As a mathematics education community, we must do a better job of helping students see that mathematics was created, and is still being created, to address real-life situations. We must acknowledge that technology exists today that didn't 10 or 20 or 30 years ago and yet, in many places, the mathematics content has changed little. Students often wonder why they are being required to memorize a procedure that technology will do almost instantaneously; they don't see a reason why mathematics should be learned.

This need to update content is especially true for secondary schools in order to help students see the relevance and usefulness of mathematics. Modernizing the mathematics content could lead to students wanting to take more mathematics courses. Technology, including artificial intelligence has implications for what and how we teach. If the questions we are asking are easily solvable for tools like ChatGPT or PhotoMath, we should change the questions we're asking. For students to see the relevance of learning mathematics, questions must be posed that involve more than following a procedure that technology can easily and quickly perform. Instead, students must be provided opportunities to make sense of the concepts being learned and to model situations with mathematics. Too often students leave school thinking mathematics is about doing worksheets correctly! We know that professional mathematicians don't do worksheets, but instead use those procedures to model situations; more of this must be done in schools as well to help students recognize the relevance and usefulness of mathematics. Learning mathematics must also involve helping students develop necessary justification skills to support their reasoning.

THE IMPACT OF TECHNOLOGY

I sometimes hear educators say that artificial intelligence should be banned from our classrooms. This seems naïve to me. We should recognize that students aren't in school all day and they will use it outside of the classroom whether we allow them to or not. Instead, we should help students discover how to both appropriately use these tools as well as recognize the potential pitfalls. If we are truly interested in helping our students become career and college ready, we must recognize that many careers utilize artificial intelligence, and we should be helping prepare our students to appropriately use it.

Effectively integrating technology into mathematics should lead to increased opportunities for mathematical modeling to help students see the usefulness of mathematics. Mathematical modeling encompasses ideas such as problem solving and real-world application, which are critical features of a mathematics learning program that develops students' capacities to use mathematical tools in meaningful ways. Although some definitions may differ, mathematical modeling goes beyond contextual problem-solving and application to include a cycle of activity involving determining which components of a situation to mathematize and how, creating models, interpreting results, and revising models to attend to different factors and ultimately improve the efficacy of the model.

High school mathematics learning experiences should consistently focus on reasoning and justification, relevance and application, and learning mathematics concepts through an analysis of real-life phenomena to help students make the necessary connections. Students should be taught to use mathematics as a tool to explain, analyze, investigate, and model situations that exist in life. Students should be provided with opportunities to solve meaningful, real-life problems and use mathematics as a vehicle to make sense of authentic situations.

Too often, mathematics instruction focuses on covering content and filters students into courses that marginalize students rather than on practices that nurture students' positive mathematical identities and promote deep understanding of concepts. As a result, students who enter school with an interest in mathematics often leave with no desire to continue learning mathematics. Often, an overwhelming majority of students leave secondary schools feeling incapable of learning mathematics which can limit future opportunities.

In order to truly effect change and increase opportunities for all students, the goal of learning mathematics must be analyzed and agreed upon as varying goals lead to drastically different experiences for students. The goal of learning mathematics depends on what one sees as the purpose of learning mathematics. Often people view learning mathematics as a step to getting a well-paying job. While this is a valid reason, it should not be the only one. At different times through the history of the United States, as well as in other countries, learning more mathematics and science is advocated for to keep one's nation safe and secure, both physically as well as economically (Tate, 2013). Again, these are not bad reasons to learn mathematics, but there should be more.

MATHEMATICS EDUCATION FOR THE FUTURE

We should also want a global society that is math literate and can understand and critique the world. Mathematics is incorporated in so many areas of daily life, including transportation systems, medicine, finance, and the ever-growing use of "big data" (NRC, 2011). Individuals should be able to look at data and determine the validity of conclusions that are reached. They should be able to look at graphical representations of data and identify any misleading features that often lead to incorrect conclusions.

There has been increased attention on data science in the United States, especially at the high school level. While there is much work to be done, conversations are occurring on clearly defining what data science should look like, who should teach it, and what mathematics needs to be in the course in order for it to be considered to receive a mathematics credit. As data increase and more decisions are being based on data, students must develop a deeper understanding of the methods and ethics associated with collecting, analyzing, visualizing, and communicating data. When data science skills are incorporated into mathematics courses, it can help students see the relevance and utility of the mathematics they are learning. By building data science into the math curriculum and integrating more datasets relevant to students' lived experiences, we can change the perception of mathematics as following rote procedures and inspire more interest in the subject as a whole.

One of the challenges facing data science is the perception among some that this is a course for those unable to do well in calculus. Attention must continue to be paid to help all see that data science is a course equivalent to calculus in rigor and comparable in positioning for future STEM opportunities. n fact, for many students, a course in data science might be far more applicable to

their lives and future careers than a calculus course. A second challenge facing schools is who should teach it. Because data science is an integration of several content areas, including mathematics and computer programming, it can be difficult to find someone who is certified and has the necessary background to teach such a course. The need for teacher professional development is evident in order to successfully incorporate data science into schools.

Students need the opportunity to play with the mathematics around them. Su (2017) suggests that play is a desire that can lead people to flourish. Su asserts that

> […] mathematical play builds virtues that enable us to flourish in every area of our lives. For instance, math play builds **hopefulness**—when you sit with a puzzle long enough, you are exercising hope that you will eventually solve it. Math play builds **community**—when you share in the delight of working on a problem with another human being. And math play builds **perseverance** […] math investigations make us more fit for the next problem, whatever that is, even if we don't solve the current problem.
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> Su (2017, pp. 485–486, original bold)

Students may begin their formal education with a sense of looking for the joy in mathematics. But far too often, that joy is squashed through the sorting of students into ability groups in the elementary grades and then by tracking in the middle and high school years. Teachers and schools begin the process of sorting students by perceived ability and readiness to learn into homogeneous groups. Unfortunately, these different groups receive drastically different mathematics education experiences. Those who are perceived to be struggling are frequently taught mathematics by memorization and are presented with "tricks" to help them remember how to successfully perform a procedure that results in a correct answer, which can limit their opportunities later on. But those who are perceived to be advanced are presented with rich problem-solving activities and are encouraged to make sense of the mathematics rather than merely memorizing what to do. This inequity in teaching leads to drastically different outcomes with those placed in less rigorous curriculum having lower achievement in mathematics (Stein et al., 2011).

PEDAGOGY NEEDED

What message do we send to our students when we present mathematics as a series of tricks? Do we send the message that mathematics is understandable, or do we send the message that mathematics is so difficult that they need to resort to tricks to get the correct answers? It is our responsibility to ensure that students see the relevance and usefulness of mathematics, and a steady stream of tricks won't help convince them of this. I want students to recognize that mathematics was and is being developed to explain the world. Memorizing a set of tricks does not promote this recognition.

Along with considering why and how students are grouped, it is vital to examine the instructional practices used within the mathematics classroom. In too many classrooms, the teacher stands in front and delivers step-by-step directions that students are expected to memorize and then do a set of practice problems. This memorization of steps without meaning does not have longevity and is an unproductive success at best and a destructive practice at worst. Much more attention must be paid to focus on student aspirations and interests to help them believe they are capable as doers and users of mathematics in order to increase opportunities in life.

In *Principles to Actions*, the National Council of Teachers of Mathematics (NCTM) provides eight research-informed Mathematics Teaching Practices (NCTM, 2014). No matter the set of standards being taught, these instructional practices provide the essential elements to help all students learn to become mathematical thinkers and be better prepared for any academic career or professional path they may choose. Key to these practices is having students develop a deep understanding of the mathematical content through dialogue. Students must be communicating with each other, and hearing the reasoning and explanations of others as they develop a conceptual understanding of the material. This conceptual understanding then leads to the development of procedural fluency (Smith et al., 2017).

Educators must also pay attention to the development of their students' mathematical identities. Aguirre et al. (2024) define mathematical identity as "the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives" (p. 37). Now, more than ever, educators must focus on student reasoning and sense making of the mathematics and to help them see why mathematics is so powerful and important. Doing so aids in students developing a positive

identity as being capable of learning mathematics and better allows them opportunities to be successful in whatever academic career or professional path they may choose. Our society depends on people who are able to think deeply, justify reasoning by explaining their thinking, and address issues using mathematics.

The time is now to examine the mathematical content, policies and instructional practices in order to increase opportunities for success for our students. We must continually work towards a more just, equitable, and inclusive mathematics education system for all students. This includes challenging our own beliefs about what each student can learn and do, about what mathematics is important for students to learn, and about how mathematics should be taught. We must engage in the collegial and challenging conversations and in sustained efforts on multiple levels to engage all stakeholders in the mathematics education in the work of improving learning experiences and outcomes for each and every student.

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