Editor's Perspective Article: A New Vision for Mathematics Education: Mathematics for the Mid-21st Century

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Abstract

The focus in this issue's second Editor's Perspective article is on creating a new vision for mathematics education for the mid-21st Century. For a long time, we have been approaching teaching mathematics from an antiquated perspective. Today's young students will spend most of their careers in the mid-21st Century in which many of the skills our parents and we learned in school will no longer be necessary in the same way that we no longer have gas lamp lighters, elevator operators, or people who deliver milk or ice to homes. Just as it is not a tragedy that most readers cannot use an abacus, it will not be a tragedy that our children and grandchildren will not know many of the mechanical procedures that made up the core of mathematical learning for centuries. In this article, a new vision for mathematical teaching and learning will be presented as we look toward the mid-21st Century.

Keywords: mathematics education, future of education, technology

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In spring 2018, I visited Shanghai, China to conduct professional development with teachers and to observe and give feedback on classroom instruction in Shanghai schools. In one sixth grade mathematics class I observed students solving systems of linear equations such as the following: $2x + 3y = 8$ and $x – 3y = -5$. By using Gaussian Elimination, we find the correct answer to be (1, 2). There are also numerous real-world examples in which one could use this approach. I was impressed with the sixth grade students' mathematical abilities in solving these types of problems. I thought about my experience with American students and how many do not get exposed to this type of algebra until later on in their schooling. A thought came to me. I realized that in both Chinese and American schools learning how to solve systems of linear equations is mostly mechanical and something that a simple computer program can solve today. The utility of many mathematical rules, formulas, and procedures are simply no longer necessary. We are currently experiencing an incredibility rapid technological development including technology that can solve most routine mathematics problems for us. We will need to completely change our approach to mathematics education in the near future.

The focus of this article is on creating a new vision for mathematics education for the mid-21st Century. For a long time, we have been approaching teaching mathematics from an antiquated perspective. Today's young students will spend most of their careers in the mid-21st Century in which many of the skills our parents and we learned in school will no longer be necessary in the same way that we no longer have gas lamp lighters, elevator operators, or people who deliver milk or ice to homes. Just as it is not a tragedy that most readers cannot use an abacus, it will not be a tragedy that our children and grandchildren will not know many of the mechanical procedures that made up the core of mathematical learning for centuries such as solving systems of linear equations by hand and perhaps not even having multiple tables memorized. Students in the future may not know how to solve any mathematical problems by hand in a mechanical manner. This does not mean that students will not know how to solve mathematical problems, indeed they will be much better at it, but students will use technological applications for the mechanics and dedicate their time to learn deep mathematics understanding and applications in the real-world. In this article, a new vision for mathematical teaching and learning will be presented as we look toward the mid-21st Century.

Nearly two years ago I provided some thoughts on the impact of disruptive innovations on the future of education (Evans, 2018). In this article I am taking this idea another step further in exploring what mathematics education could look like in a few short decades. My new vision for mathematics education is to move completely away from most of the mechanical procedures we currently teach toward a new approach completely centered on conceptual understanding, problem solving, use of technology, and real-world applications. In other words, I prefer to remove mostly all mechanical procedures from the curriculum that can either be done efficiently through the use of technology we currently have or will have fairly soon. This means that students do not need to memorize multiplication tables, do not need to know the traditional algorithms for additions, subtraction, multiplication, and division. They do not need to how to add fractions with unlike denominators or solve most algebraic or calculus problems by hand. Computers can find the unknown variable and computers can find the derivative or integral for us. Logarithms are mostly unnecessary for most people since we do not use them to make arithmetic easier any longer. We do not need to know how to conduct a *t*-test or ANOVA by hand since software is much more efficient, and practical, in doing so. Apps such as Photomath

can now solve many of the routine problems students solved in the past. We can replace the mechanics with better mathematical thinking. We can spend time truly developing number sense for children and focusing on what procedures are necessary in which situations, and why students will choose the operation they do. We can focus on understanding fractions and how they are applied in the real-world. We will teach students to apply algebra and calculus to real-world problems and interpret the outputs that the computer will provide. We will teach students to understand how to sort and use large amounts of data, and which statistical test would best answer our research questions. We want students to know when to choose a statistical test, how to run the test using software, and how to best interpret the results they find. Statistical analysis for good decision making will be the focus.

Even today, some mathematical mechanics have become unnecessary and outdated. For example, it is no longer that common to learn how to take the square root of non-perfect squares by hand (e.g., the square root of 10). I learned how to do this in elementary school, and my brother, who went to the same school and is four years younger than I am, told me that he did not learn how to do this. It is possible that between my time and his, this cumbersome procedure was removed from the curriculum to make space for better mathematics. Most of my current students tell me they never learned this procedure. The only time I ever use this procedure as an adult is to make an example of it to my own students, particularly with my New York City Teaching Fellows (NYCTF, 2018a, 2018b) alternative certification teachers who are currently teaching their own classes in the schools. The procedure is not at all necessary. Another example of a mechanical procedure disappearing from instruction is excessive long division. In many cases, students do not know how the algorithm truly works anyway, and many students are painstakingly going through the motions.

Removing the mechanical procedures from the curriculum will make mathematics more engaging and interesting for students. When students think about the drudgery of mathematics class, it is often something very boring and tedious such as long division and adding fractions. Real-world applications with heavy reliance on technology to solve problems will energize the mathematics classroom and perhaps spark more interest in STEM careers for young students. It will allow more time for discussion on important topics. While the focus in this article is on mathematics, it is possible to apply the same way of thinking to other subject areas. For example, software has rendered the ability to accurately spell many difficult words entirely useless. Soon, software will better correct our grammar and change the way in which we write. Perhaps a focus on verbal communications would be more beneficial since the impression we leave on colleagues is highly dependent on how we present ourselves. The software will take care of our writing for us. Reading comprehension will continue to be highly important for at least the foreseeable future. The Internet has already rendered much of what we learn in history class to be useless facts. Moving toward in-depth discussion on the implication of historical events would be more interesting for many students. Software will likely make learning another language highly impractical as software will translate what we need to say to our listener, and vice versa, in real time. Linguists will argue there are cognitive benefits to learning another language, and they are correct. However, I am not yet convinced those benefits will outweigh moving toward other important topics of learning in school. We no longer focus on Latin or Greek instruction, so perhaps our thinking on language may shift in the near future as well. For many years I have argued in favor of students going through the drudgery of many of the more boring and

impractical mathematical skills that lead to "mathematical maturity" and carry certain cognitive benefits. I am no longer convinced those benefits are worth the time we invest.

The question we must ask ourselves is: What is the purpose of learning mathematics? If it is simply to perform the mechanical procedures, then perhaps our current curriculum is the correct one to have. If the purpose is something deeper and more meaningful, then perhaps the mechanics are nothing more than tools to help us with better mathematics, and perhaps the tools are better served as computers, phones, and software rather than paper and pencil.

In the future, learning will still be about relationships with others. Teachers will still connect with their students, and students will connect with each other. This is how we will continue to best teach and learn. However, the means of achieving deep learning will shift radically in a very short period of time if we want to do the best we can for our students.

Additionally, there may be more time for teachers to focus on a process I have developed, Cognitive Reframing Theory in Mathematics (CRT-M), which is a teaching process in which the teacher uses techniques to increase a student's self-efficacy in mathematics, increase persistence, and reduce mathematics anxiety. The purpose is to "reframe" the student's mindset and improve the student's disposition, which will also have achievement and learning benefits for the student.

We are at the time in which a bold step forward is necessary to truly prepare students for their futures. It will not be easy and will require a lot of work on our parts. It will mean completely re-envisioning the curriculum. However, I do not see any other choice we have if we wish for our students to be truly educated in the mid-21st Century.

References

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