

# Advantage of Technology to Teach Engineering Mathematics

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## Abstract

While many engineering educators have proposed changes the way mathematics is taught to engineers, now the main focus is on how to utilize technology in teaching mathematics. Though work from the mathematics teaching research committee suggests that it may be beneficial to consider a broader notion of mathematics: technology and mathematics content knowledge, we want engineering students to learn mathematics using technology and use of resources and practices. If we further consider the technology and mathematics material resources available to students, and the mathematical practices students engage in, we have a more complete understanding of the breadth of mathematics using technology necessary for engineering practice. This article further discusses each of these aspects of technology and other examples of technology practices based on the authors' previous empirical studies of engineering students and practitioners' use of mathematics. This article offers insights into the teaching of mathematics to engineering students using certain technology.

## 1. Introduction

Technology in this context includes computers with appropriate mathematical software, Internet and other digital resources such as handheld computing tools and their extensions, new emerging forms of similar devices and applications. Technology can be used in a variety of ways to improve and enhance the teaching and learning of mathematics. It can be used to facilitate mathematical discovery, understanding, and connections that may be difficult or impossible

without its use [1]. The computational and graphical capabilities of current technologies enable users to efficiently generate and manipulate a variety of representations of mathematical ideas and processes. Activities that engage students in connecting multiple representations (e.g., graphical visualization, numerical solving, geometrical and algebraic), and those that invite students to analyze or create images, visualizations, and simulations provide wide-ranging opportunities for mathematical exploration and sense making. Technology can reduce the effort devoted to tedious computations and increase students' focus on more important of mathematics. Equally importantly, technology can represent mathematics in many ways that help students understand concepts. In combination, these features can enable teachers to improve both what and how students to learn mathematics using technology.

## 2. What Is Mathematics?

Standard dictionary definitions of mathematics as, "*the abstract science of number, quantity, and space*" that indicates more about the origin of mathematics than about mathematics as it is understood today. Mathematics is no longer restricted to "number, quantity, and space"; it has been extended to include strings, physical, graphical structures, and many other types of objects in our world. Abstract structures defined long ago have proven to be useful in understanding things that were devised quite recently. Mathematicians work by defining abstract structures and then studying their properties. The structures may be very basic and general such as relations and sets or more complex, algebraic structures comprising several sets and

functions mapping between them. A structure is defined by describing properties of the set members and the functions.

### 3. Reality of Mathematics Education

A Survey done by many colleges reveals that the curriculum requirements for mathematics education varies from program to program [12]. However, all math education programs have similar elements mentioned which are below [2]:

- ❖ Students knowledge major in mathematics.
- ❖ Students must pass a culminating mathematics content exam.
- ❖ Students are required to use technology in mathematics.
- ❖ Teaching mathematics with specific technology to be integrated into engineering courses.
- ❖ Students take professional education courses and specific pedagogical content courses.
- ❖ Students have to reach useful field experiences.

### 4. Advantage of Technology to Use in Mathematics

In general, all engineering students should be familiar with the following mathematics topics such as "Matrices, Vector Calculus, Linear Algebra, Single and multi variable calculus, Ordinary Differential Equations, Partial Differential Equations, Probability and Statistics". Usually, all these topics are taught in separate mathematics subjects. They are usually not incorporated into the teaching of engineering subjects. When mathematics teachers introduce these topics in teaching, they usually does not make any reference to the underlying engineering subject or practical problem that lead to the mathematical equations. Students thus find it difficult to recognise the relevance of learning all these difficult methods to solve a set of equations. One of the reasons for this problem is because mathematics is usually taught as an isolated subject, distancing itself from the engineering science subjects that generate mathematical equations and uses the solution to the equations. The main reason for teaching mathematics as a separate subject is that many engineering disciplines need similar mathematics for solving similar sets of equations. This model is efficient from an administrative perspective, but the pedagogical benefits to the students are questionable.

There are more issues associated with the teaching of engineering mathematics than merely deciding on how the teaching of mathematics can co-exist with other engineering subjects. And one important issue to consider in the teaching of mathematics is the emergence of Computer Algebra System (CAS) software[3]. CAS is computer software packages which have incorporated all the rules and methods of *pen and paper* mathematics into a computer program. Hence, all the pages and pages of complex and routine algebra that students are required to perform can now be done on a computer by merely entering the relevant commands into the CAS software. With CAS becoming more accessible, some educators have questioned the need to teach (old fashioned) *pen and paper* analytical mathematics. Why learn to memorize all these mathematical "recipes" when all one needs to do is to type the equation into a computer and instantaneously obtain the solution? This is an important question to raise but the value of analytical mathematics must not be dismissed. Analytical mathematics nurtures critical and logical thinking skills in engineering students. These are very important skills for engineers to possess. But using CAS in the teaching of mathematics adds a new dimension to the subject. The added value of incorporating computer graphics and animations available in CAS to help students understand intricate mathematics ideas is unquestionable. The main benefit of CAS is not to replace the didactic lecturer. In fact, most educators use CAS to enhance their lectures. CAS are typically used in a "mathematical laboratory" environment where students are asked to work in teams to solve short assignments designed to give students a deep understanding of complex but important ideas in mathematics. It has been found by many engineering educators that performing exercises in laboratory sessions provide students with a healthy grasp of complicated mathematics concepts that are of paramount importance to engineering students.

### 5. Types of Technologies for Teaching Mathematics

Technology has become an essential tool for doing mathematics in today's world. It can be used in a variety of ways to improve and enhance the teaching of mathematics. As NCTM (2000) highlights in its standards, technology can facilitate mathematical problem solving, communication, reasoning and proof[8]; moreover technology can provide students with opportunities to explore different representations of mathematical ideas and

support them in making connections both within and outside of mathematics .

### 5.1 What type of technologies are useful tools for teaching engineering mathematics?

Computer Algebra Software (CAS) are computer software packages that can perform *analytical* mathematics calculations. All the complicated symbolic manipulation that students learn in high school can now be automated with CAS. Some of the more popular CAS packages are *Maple* (<http://www.maplesoft.com>), *Mathematica* (<http://www.wolfram.com>), *Mathcad* (<http://www.mathcad.com>), *Matlab* (<http://www.mathworks.com>), and *Derive* (<http://www.chartwellyorke.com/derive.html>). *Geogebra* (<http://www.geogebra.com>), *Scilab* (<http://www.scilab.com>), another feature of CAS is its ability to provide advanced graphical illustration of complicated mathematical solution. This makes it enormously easier for engineering educators to perform exercises and apply mathematical subject matter to engineering problems. Garcia *et al.* (2005) has found that these entities are especially useful and appropriate for teaching and learning purposes. A study conducted by Comacho and Depool (2002) found that the appropriate use of CAS helps motivate teacher/student to teach/learn and understand mathematics. The role of engineering educators is to encourage teacher/students to use these tools to understand the full extent of the ability of mathematical models to solve "real-life" engineering problems.

## 6. The Role of Technology in Teaching Mathematics

- ❖ The visual and numeric supports offered by computers and graphing calculators are helpful for students to create meaning for expressions and equations [10].
- ❖ We need to teach students to learn to recognize technology when they need help by asking the teacher, a fellow student, or using tools such as computer software, the internet, or a graphing calculator [11].
- ❖ A large number of empirical studies of calculator use, including long-term studies, have generally shown that the use of

calculators does not threaten the development of basic skills and that it can enhance conceptual understanding, strategic competence, and disposition toward mathematics [10].

- ❖ Confronted with a complex arithmetic problem, students can use calculators and computers to see beyond tedious calculations to the strategies needed to solve the problem [10].
- ❖ Technology can relieve the computational burden and free working memory for higher-level thinking so that there can be a sharper focus on an important idea [10].
- ❖ Skillfully planned calculator investigations may reveal subtle or interesting mathematical ideas, such as the rules for order of operations [10].
- ❖ Calculators can have a useful role even in the lower grades, but they must be used carefully, so as not to impede the acquisition of fluency with basic facts and computational procedures. Inappropriate use of calculators may also interfere with students' understanding of the meaning of fractions and their ability to compute with fractions [13].
- ❖ Graphing calculators can enhance students' understanding of functions, but students must develop a sound idea of what graphs are and how to use them independently of the use of a graphing calculator [13].
- ❖ Engagement, mathematics confidence, confidence with technology and achievement are interrelated for high achievers in secondary school mathematics.
- ❖ Using technology like educational gaming in the classroom will be a fundamental catalyst for transforming education.
- ❖ Technology and multimedia tools can help personalize learning and keep students engaged.
- ❖ Technology is also a means to sharing best practices throughout the education community and encouraging open-source technologies to foster social networking.

- ❖ Classroom networks support student achievement in mathematics [9].

## 7. How does Technology to Enhance Mathematics Teaching?

### 7.1 Visualization

Use technology to harness the power of **2D&3D** visualization to help students make connections, deepen understanding, and further develop:

- ❖ Spatial reasoning ability.
- ❖ Geometry in depth study.
- ❖ Connections between mathematical representations and technology.

### 7.2 Efficiency

- ❖ Get into appropriate depth and complexity by using technology to teach concepts and skills more effectively.
- ❖ Think of more examples and give a variety of examples.
- ❖ Teach mathematics in depthly.

### 7.3 Connect Mathematics and Technology

- ❖ Use technology as a bridge to connect students to mathematical context.
- ❖ Use comparison to highlight similarities and differences.
- ❖ Encourage discussion of strategies, opinions, and ideas in the classroom.

## 8. Conclusion

Mathematics educators are attempting to address the numerous challenges faced in the teaching of enabling mathematics to engineers, in a number of innovative ways. The key challenge is the decline of mathematical preparation of students entering engineering first year and the increased variability of their knowledge. This is compounded by the decreasing numbers of mathematics staff, with increased pressure to produce research and the decrease in mathematics enabling subjects in engineering degree programs. Web softwares such as Weblearn, CalMaeth and Wolframalpha appear to be effective in providing additional practice with feedback for students without further burdening

limited staff with extra marking. Learning resources such as video examples also provide students with 'virtual staff assistance'. The major advantage of these resources is that they are available to students to access at their convenience. Mathematics subjects that have been designed through the collaboration of mathematics and engineering units are more likely to be effective. Joint ownership of curriculum design is particularly important when different branches of engineering that regard different mathematics topics as essential, are being serviced within a limited number of mathematics subjects.

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