Bring Learning to Life
A collection of Maplesoft customer application stories
Discover how educators are using Maplesoft solutions for every aspect of technical education.
A Word from Maplesoft’s President

Welcome to the Maplesoft magazine, Bring Learning to Life, a collection of stories about the use of Maplesoft products in the classroom.

Educators from around the world use Maplesoft technology for teaching Science, Technology, Engineering and Mathematics (STEM) courses. From teaching calculus to 11-year-olds, to exploring engineering concepts, Maplesoft solutions apply to every aspect of academic life. For over 30 years, our technology has been helping teachers teach, students learn, and administrators provide cost-effective strategies for student success in STEM education.

Used creatively, Maplesoft technology can help students learn better and faster. It can illuminate theory, clarify the abstract, and give form and substance to general principles. We are continually impressed by the many different uses customers make of our technology. The stories in this collection illustrate just a few of the many ways Maple™ and MapleSim™ have been used to enrich the classroom and deepen student understanding.

Please enjoy this collection with our thanks for all the passion and support the Maplesoft community has shown to us over the years.

To learn more, please visit www.maplesoft.com/learning.

Sincerely,

Dr. Laurent Bernardin
President and CEO
Maplesoft
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Dr. Joshua Holden, Mathematics Professor at the Rose-Hulman Institute of Technology, is a proponent of what he calls the “rule of four” in teaching mathematics. He believes that math concepts should be expressed not only in formulas, but in words, pictures, and tables. He considers Maple, the technical computing software from Maplesoft, a powerful tool in his efforts to help students better visualize mathematics.

“It is really easy and useful to visualize math concepts in Maple,” says Dr. Holden. “I can quickly draw 3-D images of complicated concepts that would not be possible without such a tool. Using Maple, I can make students work with large amounts of data in tables - data that is too large to compute by hand – letting them see different patterns and trends. Not only does this help them understand the math better, but it keeps them more engaged and eager to learn more.”

About 2000 students use Maple as part of their curriculum at Rose-Hulman. The institute’s laptop program ensures that each student has access to a laptop, making it much easier for students to work with Maple whenever and wherever they happen to be. Dr. Holden especially appreciates that when he illustrates an example using Maple, students can create the same example and experiment with Maple on their laptops during his lectures. He says this saves time in the classroom, and also makes the students less dependent on the instructor.

Dr. Holden particularly appreciates Maple’s Clickable Math™ tools. Maple’s palettes, interactive assistants, context-sensitive menus, and tutors, make it easy to learn, teach, and do
mathematics. “These tools in Maple help students explore the math on their own, and I save the time I would otherwise spend teaching them commands for these functions. It also avoids mistakes – even small ones – that can be time-consuming to fix,” says Dr. Holden. “Students still have the option of using the command-driven interface in Maple, but that’s not how they interact with computers any more. They are used to commands that are just a click away.”

In his calculus class, Dr. Holden gives students self-guided activities that they complete using Maple. These projects often involve Maple worksheets with large datasets that would be tedious to complete by hand. Using Maple and its clickable features, he says, students can get over the tedious part quickly and move on to the more interesting parts of the problem. In fact, it is Maple’s attractive, easy-to-use interface that Dr. Holden considers to be Maple’s biggest strength. “Maple goes out of the way to make the learning curve as short as possible. Compared to other tools, this is Maple’s biggest advantage. Another feature I like in Maple is its ability to combine good-looking mathematics with interactivity. With other tools, you get one or the other; to get them both in one is difficult. But with Maple, I can create sophisticated documents with attractive mathematical expressions that have interactive features. The mathematical expressions show up exactly like in textbooks, and that’s exactly how students should see it.”

Dr. Holden also uses Maple for illustrations in the area of math and art. “I write programs with sophisticated computations in Maple and convert them into graphical images which have some artistic value,” says Professor Holden. “Images are the best way to get the point across and Maple really lets me make the graphics quickly and easily.”

Dr. Holden also appreciates the MapleCloud Document Exchange, which facilitates easy sharing of Maple documents. He believes it is the best means to share Maple documents with and between students, in an age where they are used to online networking and internet sharing.

Apart from the benefits in teaching and learning, Dr. Holden says Maple helps prepare students for the real world. He says students come into the class with the notion of computers as toys, and their interaction with tools like Maple and the discovery of what they can and cannot do with such tools gives them a whole new perspective. They see the breadth and depth of the different resources that are available to them, and they start looking at sophisticated computer programs as tools that can empower them. “Technology is such an integral part of student life, and the use of tools like Maple is fundamental to a successful classroom experience,” concludes Dr. Holden.

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The freshman design engineering course, or “cornerstone” course, is a critical component of the curriculum at most institutions. It introduces students to the fundamental techniques of design and the various tools of engineering. The modern incarnation of this course integrates general design and analysis concepts and the application of computing tools such as CAD. In a general sense, it is intended to answer the question “What do engineers actually do?” for a young student.

During a recent initiative to enrich its cornerstone course, McMaster University introduced MapleSim into their engineering course curriculum. MapleSim is physical modeling and simulation software that allows students to analyze and explore the system dynamics, and ultimately the design options, for a real system. Prior to the introduction of MapleSim, McMaster’s cornerstone course focused on development of the CAD solid model based upon the dissection of an existing product. Students were exposed to existing designs, but possible design modifications were not considered. This is typical of most traditional freshmen design and graphics courses where often CAD models alone form the core of a design project.

The problem is that when using only CAD tools there is no real opportunity to apply good engineering analysis, which is fundamental to understanding and retention. At the freshman level the engineering information that the students are learning is too detailed and complex for them to do much more than create the CAD drawing.

There are approximately 1000 first-year students entering engineering studies at McMaster University each year, and all of them take the same first-year courses, specializing later in their second year. Dr. Thomas Doyle, Assistant Professor of Electrical and Computer Engineering at McMaster University, wanted to find a way to increase the engagement of these first-year students by providing them with both practical knowledge and an understanding of the theory behind engineering design.

"Using MapleSim, students can visualize primary movements of an engineering system and identify design defects readily," says Dr. Doyle. "The MapleSim software, although extremely powerful, has been presented in a way that is very easy to use, such that freshmen can design, operate, and build complex models."

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— Dr. Thomas Doyle, McMaster University

Working together with Dr. Doyle, Maplesoft engineers built polished MapleSim models that adapted information from the CAD designs created by the students in Autodesk® Inventor®. As a result, from the CAD model the students were able to quickly develop a corresponding dynamic model using MapleSim and systematically assess hand calculations and system performance. Students were then able to manipulate the model configurations and explore the design parameters. Pedagogically this meant that the students’ projects now had a complete engineering design iteration process – i.e. they can analyze possible designs, run simulations, do engineering “what if’s,” and gain design experience that is not typical of most freshmen design courses. As a result, the students had a deeper understanding of fundamental engineering concepts.

"Using MapleSim, students can visualize primary movements of an engineering system and identify design defects readily," says Dr. Doyle. "The MapleSim software, although extremely powerful, has been presented in a way that is very easy to use, such that freshmen can design, operate, and build complex models. In my first year teaching the cornerstone course using MapleSim, I witnessed better designs and true engineering insights in the final results of the students’ projects. As a result, MapleSim is now a mandatory component for every engineering freshman at McMaster University."
Using appropriate technology in the classroom can have an overwhelming impact on education. Proper digital tools can create a more streamlined learning process and enhance students’ understanding of the subject matter. This is especially true in mathematics courses, where students are regularly dealing with complex materials. Matthew Westerhoff, a professor at Northern Virginia Community College (NVCC), uses Maple to improve his students’ conceptual understanding. Maple’s many features and powerful math engine allow students to work through complex calculations and functions quickly and efficiently.

Teaching at NVCC since 2005, Westerhoff first used Maple when he was a student. His courses required him to learn basic commands and features, including plotting 2-D and 3-D functions, and calculating derivatives and integrals of complicated expressions, which were invaluable in his learning. Westerhoff’s positive experiences with Maple prompted him to use Maple in his teaching and in his research projects as well. “Maple makes work more efficient and saves time on difficult calculations,” Westerhoff said. “You can quickly complete calculations that would take hours to do by hand. At the beginning of the semester I tell my students that using Maple does three things: it helps them develop greater focus, makes them more attentive to detail, and allows them to become familiar with using a computational tool. The first two skills are critical for learning mathematics.”

Westerhoff uses Maple extensively in various courses, including Calculus, Linear Algebra, and Differential Equations. He requires his honors students to learn Maple so they can understand how to effectively use a computational software tool and apply it to solving math problems. “Compared to other math software, Maple handles symbolic calculations better and the help options provide detailed examples,” he said. “I like Maple because of how detailed it is when it comes to performing calculations, as well as the many available options it has for graphing functions. I also like the MapleCloud feature where users can share their Maple creations with each other.”

The graphics in Maple are something Westerhoff finds extremely useful in his classroom, as they allow him to plot systems of equations and visualize planes in three dimensions, which is very beneficial in a linear algebra course. In his Calculus courses, he uses Maple’s Riemann Sums and Volume of Revolution tutorial packages because of the interactive graphics they provide. “The tutorial packages let you choose the type of numerical integration scheme you want,” he said. “The slope fields section in the DE tools package is also an excellent tool for my Calculus and Differential Equation courses because it allows students to visualize the slope fields of the function.”

The first Maple assignment that Westerhoff gives his students is a tutorial on how to use Maple. The main purpose of this assignment is to get the student comfortable with using the software. It consists of commands that students have to type in and execute. Other Maple assignments consist of problems related to the topics being discussed in class that students must use Maple to solve. Some of the assignments require them to modify or tweak a Maple code to make it solve a provided problem of interest. “Most of the students enjoy using Maple, especially those pursuing careers in a STEM field,” Westerhoff said. “Many of the students tell me that once they became comfortable with Maple, they started finding and appreciating numerous benefits from it.”

Since Westerhoff introduced Maple, students are able to grasp concepts better. By using Maple, students become better prepared for handling the rigors of a course. In courses where Westerhoff’s students use Maple, the class average and final exam average are significantly higher compared to courses where students were not assigned Maple assignments. “In addition to doing better, students are getting the opportunity to use a computational tool that they will most likely use as they go further into their academic studies and into careers in industry,” Westerhoff said.

Westerhoff recently had two of his students work on a possible application of the Brachistochrone Curve. The problem involves finding the fastest descent path possible between Point A and Point B in a spatial environment. One possible application of this involves a drainage pipe. The calculation of the arc length of the drainage pipe is one of the major components needed for design purposes. Due to the complexity of the equations, Maple was used to implement and solve the customizable length of the drainage pipe which is used to calculate the approximate rate of flow. One of the students presented his work at the VMATYC (Virginia Mathematical Association of Two Year Colleges) conference. This was the first time that a student had presented their work at a VMATYC conference.

The school is planning to host a Maple Training Day to promote Maple’s capabilities and further train current users. Maple has great value, and Westerhoff and his colleagues hope to see it adopted for more widespread use at the college. “Maple has been an invaluable resource for us,” he said. “It’s beneficial to both instructors and students and we want to see those benefits realized on a larger scale.”
Use of technology in the world of sports is improving at a rapid rate. New types of data, coupled with advanced engineering tools, allow for more in-depth analysis of the human body as it pertains to specific movements and tasks. As a result, motions can be refined and equipment improved to help athletes maximize their abilities and performance. John McPhee, a professor of Systems Design Engineering at the University of Waterloo (UW), has overseen several studies on the motor function of Paralympic athletes. McPhee, who focuses on modelling the interactions between athletes and their equipment to maximize athletic performance, relies on MapleSim in his research and project development. MapleSim allows his team to explore millions of design possibilities to determine the ideal solution for each subject.

McPhee and his team recently worked with the Canadian Paralympic Wheelchair Curling team to design a better wheelchair curling shot. McPhee’s team, led by Brock Laschowski, a PhD student in the Department of Systems Design Engineering at UW, conducted a study of the motor control of Paralympic wheelchair athletes, using MapleSim to model their wheelchair curling shot. Laschowski’s research is paving the way for custom-designed wheelchairs that are designed specifically for individual athletes and their respective neuro-musculoskeletal systems. The human biomechanical model consists of rigid body segments characterizing the torso, head and neck, upper arm, forearm, and hand, as well as representative hip, shoulder, elbow, and wrist joints, all of which were modeled as revolute kinematic pairs containing biofidelic viscous damping quantities. MapleSim was subsequently used to perform analyses on the inverse dynamics of the multibody system model with experimentally measured joint and stone kinematic data.

“We’ve been working with Team Canada for a few years now and it was extremely satisfying to see them win the bronze medal at the Paralympic Games in South Korea,” McPhee said. “We’re hoping for gold medals in the years to come.”

The study also gave rise to the idea of a curling end-effector, a device to help wheelchair curlers improve control over their shots. The device attaches to the end of the curler’s stick and provides greater command over the stone by pulling it back prior to release. Two more members of McPhee’s team, University of Waterloo students Borna Ghannadi and Conor Jansen, began the end-effector project in 2016 at the request of Mark Ideson, the skip for the Canadian men’s Paralympic curling team and winner of Paralympic gold (2014) and bronze (2018) medals. After being modeled in MapleSim, an initial prototype was built, which has undergone several trials and adjustments since then. The device is now on its 7th iteration - appropriately named Mark 7 - and is close to being a finished product. “It’s been modified quite a few times because it turned out to be more of a challenge than anyone thought,” Ideson said. “But we knew something could be created if we were able to get the right people on it. John and his team have come up with a great design.”

Currently, wheelchair curlers use a device that keeps the stone static before it’s thrown. Having the ability to pull back on the stone and break the friction prior to release will provide great benefit to the curlers. Certain conditions in curling, such as warm or sticky ice, or a freshly sanded stone, can cause the stone to catch or wobble on release, which leads to decreased accuracy. The Mark 7 enables the shooter to slightly pull back on the stone at the release point, thus breaking the inertia. “When you can only push forward, if the ice conditions aren’t perfect, you’re throwing at a different speed every time,” McPhee said. “If you can pull the stone back and then go forward, you’ve broken that friction and your shot is much more repeatable. This should really make the game more interesting.”

The objective was to design a mechanism that not only allowed curlers to pull back on the stone, but also had a release option with no triggers on the curler’s hand. The Mark device screws on to the end of the curler’s stick, and is designed to rest firmly on the curling handle. It can be tightened or loosened as required to fit the handle properly and provide curlers with greater control over the stone. Once the curler selects their shot, they can position the stone accordingly, slide the stone forward and pull back at the release point to separate the device from the stone.

Researchers Use MapleSim to Help Team Canada Olympians Improve Performance in Wheelchair Curling

University of Waterloo

The ability to pull back prior to release really eliminates some instability. A device like this really levels the playing field.

— Mark Ideson, Canadian Paralympic Wheelchair Curling Team
“The increased speed and accuracy of MapleSim’s multibody dynamic simulations, made possible by the underlying symbolic modelling engine, enabled the team to spend more time on system design and optimization,” said Laschowski. “Though several multibody system algorithms have been commercialized, these model codes are limited to engineering mechanical systems and don’t necessarily support features characteristically involved in biomechanical applications like muscle mechanics and activation dynamics, non-ideal human joint geometries, and biomechanical impact dynamics.”

Contrasting the aforementioned multibody software, MapleSim employs principles of mechanics with linear graph theory to produce unified representations of the system topology and modelling coordinates, Laschowski said. “The system equations are automatically generated symbolically, which enables us to view and share the equations prior to a numerical solution of the highly-optimized simulation code. MapleSim’s algorithms also support the incorporation of electromechanical components, should we eventually decide to incorporate wearable sensor technology into the system model.”

Mark 7 could have significant ramifications in the curling world. Shooting accuracy across wheelchair curling is currently around 60-62%, according to Ideson. If the curling association allows the use of new technology, like the Mark 7, that number could grow to 70 or 75%, he said. “If we can add accuracy, it’s going to improve the game overall,” Ideson said.

After a recent practice session, Ideson said the device feels good and he and his team are looking forward to having an opportunity to use the finished product. “It’s really exciting because we hope the game can improve with innovations like this,” he said. “It should help improve the level of curling across the world.”

McPhee and his team have a strong history of improving technology-driven enhancements to sports projects using MapleSim. They are currently working with Team Canada Wheelchair Basketball to model the wheelchair push in MapleSim, which will allow them to test various wheelchair configurations and determine which designs best optimize performance and speed. They have also worked with Cleveland Golf/Srixon to model a driver in MapleSim to better understand the effect of different club lengths and weights on performance, and with Hockey Robotics to develop SlapShot XT, a robot designed using MapleSim that allows manufacturers to test their hockey stick designs to improve performance and eliminate breakage.

McPhee, who has been working in sports engineering since the 1980s, said MapleSim is ideally suited to modelling athlete and equipment performance. “Its multi-domain capabilities allow us to model humans, mechanical equipment, electrical actuators and feedback sensors, all within a single environment. That greatly accelerates our model-based design and control efforts,” he said. “We’re using MapleSim to improve performance in many sports. Our list of research partners is very long and continues to grow longer. We are excited for what the future brings.”
For years, educators have been debating that the use of technology in the classroom could radically change not just how we teach our children, but what we teach them, and when. The University of Tasmania in Australia set out to prove it. Because of their commitment to embracing the Digital Education Revolution, and to showcasing how big a transformation the use of computers can make in students’ learning, the University decided to take on the challenge of teaching integral calculus to 11-year-olds. While this age group is traditionally considered far too young for this topic, which is usually introduced at age 17 at the very earliest, the University wanted to see if computer software would make a difference in their learning. If students become comfortable with this complex topic at a young age, perhaps learning could become easier and more of them will gravitate to the scientific and technical fields as they get older.

The researchers used Maple as the software of choice for this project. They used Maple to teach fifth graders the calculus curriculum used in the first-year engineering program in Australian universities. The project team trained five classroom teachers who then worked with their students for two hours a week for six weeks. During this time, the students were introduced to a series of real-world problems and mathematical concepts, and learned how to solve these problems in Maple. Students used Maple to set up the solutions to word problems, calculate results, and graph functions.
Maple is well-known for the Clickable Math™ interface that focuses on the concept and not the software. While using traditional math notation, the user interface is natural, intuitive and very easy to use. The students become instantly productive and engaged. Maple’s ability to manipulate mathematical equations algebraically, perform calculus operations such as differentiation and integration, solve equations, and graph and visualize functions and solutions helps remove the need for students to memorize dozens of different integration techniques and struggle with the mechanics of calculating definite integrals. Instead, they can focus on the higher-level concepts and develop a deep understanding of integration and its applications.

One class was selected from each of five different schools in cities across Australia, for a total of over 100 students. These schools had average or lower-than-average socio-economic advantages and the students were not selected based on academic abilities. Emphasis was put on using examples and applications that students could relate to. For example, in one problem, students chose a curve to act as a boundary for a mural in their room, and then, with the help of Maple, calculated how much paint they would need.

At the end of the program, students wrote a test based on questions taken from first-year university engineering exam papers. They used Maple to answer the questions and graph their results. 97 out of the 108 students achieved a passing mark on this test. Thirty eight students scored over 80%, showing their skill at solving complex problems using computers.

“Using Maple made a huge difference to these students, and helped showcase the kind of radical changes we can bring about,” said Dr. Andrew Fluck, lead researcher of the project and Senior Lecturer in Information Technology. “Many students perceive calculus to be ‘too hard’, which can make them reluctant to even try it. And when they do try it, their attitude can actually interfere with their learning. But based on the comments these students made after the course was over, it is clear that Maple helped spark their interest in calculus, and made them justifiably confident in their ability to handle it. Technology can be a great enabler, even for students this young.”

One of the 11-year-old students remarked how Maple had changed her perception: “Maple is wonderful to outwit Mum and Dad!” One of the girls’ fathers was amazed at the difference Maple made to his child’s learning. She said, “My dad’s an architect, so I showed him Maple. He had a go with it. He said he wished he’d had it when he was studying!”

“Maple is so easy to use, its Clickable Math™ interface has features that make common mathematical operations as simple as pointing and clicking,” said Dr. Christopher Chin, a fellow researcher on the project and Senior Lecturer at the Australian Maritime College. “This also makes it a very easy-to-teach program. And young students effortlessly learn the fundamentals of mathematics at a very early age. Students should use the same tools that the industry is using, and this early introduction will help them in the long run.”

A paper that presented this project was awarded the prestigious ‘Best Paper’ award at the International Society for Information Technology & Teacher Education conference in Nashville. Pleased with their results, the researchers intend to conduct further studies in this area, including expanding their project to teach other advanced topics in a larger number of schools. With team members - Associate Professor Dev Ranmuthugala and Dr. Irene Penesis - the researchers have applied for a bigger grant from the Australian Research Council to expand the scope and reach of the project.
University of Wisconsin-Oshkosh

Technology that is convenient and serves multiple purposes is extremely valuable. When it comes to education, such multifaceted tools can go a long way in creating a more efficient and beneficial learning environment. Digital learning tools facilitate a streamlined educational process that promotes deeper understanding and allows educators to more effectively invest their time. Zoubir Benzaid, a Professor of Mathematics at the University of Wisconsin-Oshkosh (UWO), has long used digital tools such as Maple in his classrooms to better engage his students and enhance their learning.

A mathematics instructor for more than 30 years, Benzaid was first introduced to Maple by colleagues in the 1980s. He had a keen interest in scientific software and was immediately impressed by Maple’s ease of use, introducing it into his Calculus and Applied Mathematics classes shortly after. His students initially used Maple to differentiate, integrate and graph functions, and he now uses Maple in all of his classes, due to its immense power and user-friendly interface. He started a new class several years ago in Computing Mathematics that focuses specifically on Maple and its use in applied mathematics. The class provides students with a deeper understanding of Maple’s capabilities, including experience with Maple coding. “After all these years, Maple is still a dependable and effective learning tool,” Benzaid said.

Maple’s simple and natural syntax allows users to solve problems without any background in computer coding, which makes it even more appealing for both instructors and students. It allows Benzaid to invest more time in group work with the students and participate more fully in his courses. “It has greatly improved my teaching,” he said. “I use it in all of my classes and can use it for a variety of problems and demonstrations, no matter how simple or complex.”

Benzaid regularly receives a great deal of positive feedback from his students regarding Maple. Many have expressed to him that Maple helps them better understand mathematical concepts and many others started using Maple in additional courses, such as Physics and Chemistry. “They really love the clickable aspect of the software, as it gives them the ability to quickly solve equations, differentiate, integrate, plot and more,” he said. “It also allows them to tackle more realistic and complex modeling problems.”

UW-Oshkosh and Benzaid are part of the Maple Adoption Program, which provides discounted access to Maple for students at institutions that require or recommend its use. The program is valuable as it provides access to Maple at a reasonable rate, Benzaid said. “It is a great program,” he said. “Given the price of books and material for courses, making the software affordable certainly encouraged our students to buy a copy. The Maple Adoption Program makes that possible.”

In addition to his role as a Professor, Benzaid also works with the UW-Oshkosh’s concurrent enrollment program, which allows high school students to take the university calculus sequence for university credits. The program has been in effect at the school for the past 30 years and has grown to include more than 100 high schools. “I work closely with high school math teachers at different high schools and I introduced all of them to Maple,” he said. “They all use it in their high school classes, to teach labs and assignments. It is a tremendous asset that all of them plan on using for years to come.”

Benzaid continues to be a strong proponent of Maple, and uses new packages and features in Maple such as Maple’s dynamic systems, signal processing and control design packages in his new classes.
Making Math Tangible with Maple and 3-D Printers

Texas A&M University

Maple has long been used in the classroom to help students learn mathematics through visualizations, real-world applications, interactive explorations, and other techniques that make mathematics more concrete for the students. Now, with the advent of 3-D printing, instructors have another means of making mathematics more tangible to their students. And this time, “tangible” is meant literally.

Dr. Philip Yasskin, Professor of Mathematics at Texas A&M University, has started combining Maple with 3-D printing to teach his students about solids of revolution. His Honors Calculus 2 class recently completed a project in which they designed goblets as solids of revolution, and then actually constructed the goblet so they could see, and touch, the results.

Students were asked to design a drinking glass or vase as a solid of revolution satisfying certain restrictions on the liquid capacity, volume of glass, thickness, and location of the center of mass. The students used Maple and the integration techniques they learned in Calculus 2 to define the mathematical expression whose volume of revolution met the requirements. They then graphed both the 2-D curve and the 3-D volume of revolution using Maple’s extensive plotting facilities. Once they were satisfied with both the mathematics and aesthetics of their solutions, they exported the 3-D graph from Maple into a file format understood by the 3-D printer, and printed out their object.

“The students were absolutely thrilled to learn that they would be able to actually build the goblets they had designed in Maple,” said Dr. Yasskin. “Maple has always been helpful in developing the students’ mathematical intuition in general, and the 3-D visualizations in Maple are extremely valuable when it comes to learning about topics like solids of revolution. But

Maple lets us go even further, taking that extra step from a virtual representation to a solid object and making a traditionally difficult topic much more understandable for the students.”

Dr. Yasskin is also involved in other education projects that use Maple in innovative ways. He is the founder and director of the Summer Educational Enrichment in Math (SEE-Math), an outreach program from the Texas A&M University Math Department that offers enrichment opportunities to middle school students. Each summer, talented students entering Grades 6, 7, and 8 spend two weeks exploring mathematical ideas from algebra, geometry, graph theory, topology, and more. A popular activity in the course is computer animation, where students use Maple’s visualization tools and programming language to create their own animated movies, such as growing flowers, sliding penguins, and spaceship battles. In the process, the students learn and use new mathematical skills and practise thinking algorithmically. Maplesoft supports SEE-Math every year by donating Maple licenses as prizes for the best animations.
Purdue University Calumet

Math software technology from Maplesoft is helping Professor Roger Kraft to better teach math students at Purdue University Calumet. He uses Maple, the award-winning math tool, to give students a greater understanding of the subject, help clarify concepts taught in the classroom, and deliver an interactive medium for exploring and visualizing functions.

Kraft chose Maple for his classroom because of its consistent and easy-to-use interface which enables instructors and students alike to capture the ideas, methods, and assumptions behind the math, thus delivering a better platform for teaching.

Kraft has been an enthusiastic member of the Maple Adoption Program since its inception. The Maple Adoption Program assists instructors in making easy-to-use math technology accessible to students. With the Maple Adoption Program, teachers can bring complex problems to life and students can finish assignments and projects faster, improving their understanding of even the most difficult subjects.

The Adoption Program has encouraged many of Kraft’s students to explore the power of Maple. “The Maple Adoption Program gets Maple to students at a reasonable price, thus making the software very easily accessible,” said Kraft. “The Adoption Program works very smoothly and lets us keep up with the latest versions of Maple.”

The wide and easy use of Maple has spurred Kraft to develop his own course material and homework assignments in Maple. “Maple adheres to mathematical standards and provides a unified environment for the teaching and practice of math,” said Kraft.

“The combination of the consistent user interface, math functions, and visualization tools means that students learn math faster with Maple.”

— Professor Roger Kraft, Purdue University Calumet

One Maple homework assignment, for example, asks students to plot a parametric surface. Students interactively explore the solution space by writing down equations in a Maple document, plotting them with Maple’s suite of visualization tools, and documenting their methods. “Maple empowers students to explore the behavior of functions as they vary constants and parameters. When students come to the course, they have weak notions of functions and equations. Maple helps them investigate the math and get a better understanding not just of the results, but of the process as well,” said Kraft.

Kraft also teaches students how to program and manipulate data structures using Maple. He finds that students quickly learn how to use Maple’s standard procedural programming language to extend the functionality. “Maple’s interactive interface helps students learn faster,” Kraft commented. “It contains an easy-to-understand description of the syntax, with a wide array of examples that instantly clarify the concepts described therein.”

Kraft intends to continue using Maple in the classroom. He concluded: “The combination of the consistent user interface, math functions, and visualization tools means that students learn math faster with Maple.”
While many look at mathematics simply as a subject one takes in school, the truth is that mathematics is the foundation for many aspects of our lives. A diverse range of professional fields – including defence, aerospace, manufacturing, automobile and even athletic equipment development - rely on mathematics to drive innovation, gather data, model performance and improve technology. It even spurs developments in the medical field, where researchers use mathematical models and data to better understand the human body and its response to various afflictions. Dr. Emmanuel Bakare, a Nigerian scientist, researcher and educator, utilizes Maple to examine patterns in infectious diseases and further understand their effects on the body.

The leader of a group called Laboratory of Modelling in Infectious Diseases and Applied Sciences (LOMIDAS), Bakare is a mathematical modeler who uses simulation models to provide insights into infectious disease trends, quantify likely benefits of public health interventions, and support risk assessment for emerging infectious diseases. His experience includes work with compartmental models, stochastic simulations, differential equations, agent-based models, time series analysis, wavelet analysis, spatial dynamics, infectious diseases control, and models parameters estimation.

While attending a workshop at the University of Cape Coast in Ghana, Bakare was introduced to Maple by some of his colleagues. Maple greatly simplifies life for modellers like him. “I find it easy to use Maple to do analysis of my disease models, and using the software has really been a wonderful experience,” Bakare said. “Maple has been helpful in tackling very difficult mathematical problems. It can do things that other math software is just not able to do. Maple has been very useful for my work and research.”

Bakare’s research is based on developing an understanding of infectious disease transmission through analysis of incidences and data from surveillance systems. He regularly explores a number of forms of data visualization and time series analysis in order to identify meaningful signals in the data. He develops mathematical and computational models of disease transmission, fits them to real data and compares different modeling techniques as a function of the type of data and the kind of question under investigation. “I use models to test different hypotheses regarding transmission mechanisms, to estimate key epidemiological parameters such as Reproduction Number, and to explore optimal interventions to reduce disease incidence,” he said. “Maple is helpful to this end as it can successfully handle large systems of equations and large-scale simulations.”

In a recent study, Bakare examined how the human body develops immunity to various diseases. Using Maple, he conducted an equilibrium analysis using a mathematical model first developed by renowned scientists Roy M. Anderson and Robert M. May. The model shows how the presence of virus cells stimulates the body to produce lymphocytes that attack and kill the virus cells. “With Maple, you aren’t forced to choose between mathematical power and usability, making it the ideal tool for research and for working with models like this,” he said.

“Maple’s powerful math engine allows me to analyze and solve mathematical problems that are critical to my work.”

– Dr. Emmanuel Bakare, Laboratory of Modelling in Infectious Diseases and Applied Sciences

Maple has many features that appeal to Bakare in his work, specifically Maple’s ability to handle complex mathematical modelling problems. His work with Maple has allowed him to find the equilibrium solution of several non-linear systems of differential equations in mathematical modelling of infectious diseases. He has also been able to solve and build iterations of other non-linear systems of equations using the Homotopy Analysis method. “The tasks Maple enables me to perform are invaluable,” Bakare said.

In addition to his research, Bakare trains his undergraduate students to use Maple to support their undergraduate modelling projects. “Maple can handle many different types of problems in a short time,” he said. “I have many projects planned with Maple. It is software everyone should have.”
As part of a process to reform STI2-D educational streams (Sciences and Technology of Industry and Sustainable Development), technical high schools in France are now required to use design and development software tools. Most schools from the Académie de Nancy-Metz, a school board in Eastern France, have chosen MapleSim, the high-performance physical modeling and simulation tool from Maplesoft.

MapleSim uses a fully-developed symbolic modeling engine to handle all of the complex mathematics involved in the development of engineering models. This symbolic engine offers unique advantages that expand the modelling and simulation capabilities of engineers. Each MapleSim release further develops these capabilities, which include automatically-generated model equations in full parametric form, equation-based custom components, optimized code generation for real-time systems, revolutionary multi-body technology, and an interactive analysis environment that captures the full engineering knowledge of each project.

The aim of the ongoing reform of STI2-D educational streams is two-fold. One, to help better separate the technological branch from the vocational branch, and two, to support high school students’ access to undergraduate and graduate education in engineering or other technical studies. Within this context, several hundred MapleSim licenses have been deployed through the Académie de Nancy-Metz.

“There were several reasons why we chose MapleSim,” said Cédric Dziubanowski, Professor of Energy Engineering at the Lycée des Métiers Gustave Eiffel in Talange, Lorraine region, France. “First, the software is already being used in the preparatory classes for the Grandes Écoles. In addition, the technical expertise in French provided by Maplesoft France has enabled us to rapidly develop advanced models in MapleSim. MapleSim’s intuitive interface makes the software a particularly easy tool to learn, both for educators and students. Maplesoft’s commercial offering is also very simple – there is no need for optional extra toolboxes as everything is integrated.”

A high proportion of STI2-D educators in the Académie are currently being trained to use the software, while some are already using it in their classrooms. Tutorials and practical assignments with application models such as a home energy management system or a solar-powered garden gate have been created. The latter example uses MapleSim’s multi-domain modelling capabilities, including multibody mechanics coupled with a battery-powered motor, with the battery charged using a solar panel.

The Académie de Nancy-Metz aims to eventually interchange models between high schools of the Académie and right across France. It is anticipated that the software will be implemented for different streams in the final years of high school.

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Académie de Nancy-Metz, France

As part of a process to reform STI2-D educational streams (Sciences and Technology of Industry and Sustainable Development), technical high schools in France are now required to use design and development software tools. Most schools from the Académie de Nancy-Metz, a school board in Eastern France, have chosen MapleSim, the high-performance physical modeling and simulation tool from Maplesoft.

MapleSim’s intuitive interface makes the software a particularly easy tool to learn, both for educators and students.

— Cédric Dziubanowski, Lycée des Métiers Gustave Eiffel

Educational Authority of Eastern France Adopts MapleSim for Use in All Technical Schools
The greatest technical accomplishments are often born from a simple idea and a lot of ambition. Such is the case with the University of Waterloo Submarine Racing team (WatSub), which began as an engineering project in December 2014. The project eventually evolved into Ontario’s first competitive submarine racing team, and appeared at its inaugural competition in July 2016. The team’s submarine, affectionately named Amy, finished 11th overall out of a total of about 135 teams at the European International Submarine Races in Gosport, United Kingdom. The concept behind the submarine races is innovation in design and the development of a cross-functional team.

Gonzalo Espinoza, a co-founder of the WatSub project and the current hull subsystem lead, was formerly an international student at the University of Waterloo and founded the team while he was in his first year of Mechanical Engineering. He was focused on aerospace engineering at the time, but found the rocketry team was bound by strict competition rules and there wasn’t as much freedom to innovate. He had no background with submarines, but was driven by the unique challenges the project presented. “I had been a member of different student teams for a full term at that point, and I realized that none of the teams was taking big risks or making bold design decisions,” he said. “On top of that, most of the teams did not involve first-year students in their design decisions, so I realized if I wanted to be involved in a team with the pace and structure that I wanted, I would have to start my own.”

The WatSub team is focused on making the fastest human-powered submarine ever created, though their main priority is exploring new designs, technologies, and fabrication techniques that expose team members to unconventional experiences they would not get anywhere else. There is also a big social aspect to the team, with all members enjoying SCUBA diving and the rush that comes from meeting tight deadlines, Espinoza said. “There are a lot of unconventional things we do and all of it is done in-house, which I believe separates us from many other student teams at UW,” he explained. “We drive a human-powered submarine in the school’s pool, we sand-cast aluminium parts, thermoform parts, develop composite monocoques (a vehicle structure in which the chassis is integral with the body) on an annual basis, urethane cast parts, and basically any other process that our members can think of.”

In developing Amy, the group used Maple to create a number-calculation platform, which supported optimization of structural components, calculation of acceleration and deceleration, and the determination of how much resin the team needed to use in the infusion of their monocoque. One of WatSub’s specific objectives with Maple was to analyze the undefined variables of the gearbox structure to understand their trade-offs and generate data to sustain the final design intent. Held together by two truss members, the gearbox must support a static load with minimal deflection. Maple was also used to optimize the propeller components of the submarine, including pitch, sectional area, revolutions per minute (RPM) and blade diameter.

The team then used MapleSim to optimize the submarine’s transmission, using similar parameters to a recent study conducting simulations for hydro electric vehicle powertrain models. “One of the reasons we prefer to work with Maple and MapleSim over the other platforms commercially available is the support we receive from the Maplesoft team.” Espinoza said, “Even with a team of students, we are able to access Maplesoft’s resources to get the most out of their products and maximize on our hard work. The fact they are a local company speaks to the highly-talented community we are part of.”

Since their first race in July 2016, the WatSub team has participated in other competitions and is constantly working on improving their designs. The team has grown to include more than 130 members and have developed Bolt, their second submarine, for the 2017 competitions.

The next step for the team is to create a Numerical-Simulations sub-team to study the vehicle dynamics of the submarine thoroughly, allowing the team to develop the vehicle to its maximum capabilities. “Our vehicle dynamic simulations are very basic at the moment - top speed, acceleration, braking distance - so there is a lot of room for improvement,” Espinoza said. “We may not be able to improve our simulations overnight, but I foresee this being a huge opportunity to maximize on the use of Maple and MapleSim in the near future.”
For the things of this world cannot be known without a knowledge of mathematics.
world cannot be made known without a knowledge of mathematics.

Roger Bacon, Philosopher and Scientist, 1214-1292
Modern digital learning tools are transforming how education is delivered, offering new ways to make education more efficient and beneficial to students, and providing instructors with the ability to maximize time and resources. Jalal Soussi, a high school teacher in Belgium, researched Maple’s capabilities for optimizing education and recently presented his findings. In addition to his role as a high school teacher, Soussi also serves as a trainer in the field of Computer-Assisted Language Learning (CALL), and is a member of a “Digital Transition” task force as part of Belgium’s Pact for Excellence in Education. Soussi has worked extensively with Maple and recently examined usage of the software for “Optimization Teaching”, based on a series of math applications he developed. Soussi’s research assessed Maple’s ability to motivate students and simplify learning, thus changing the optimization of learning. According to Soussi, various aspects of Maplesoft technology help to accomplish this, including:

- the enjoyment of handling moving objects
- the easy encoding with natural, intuitive writing
- the practical convenience of mathematical handling with ‘Clickable Math’, a feature unique to Maple that allows users to right click on the expression to explore its numeric, algebraic and graphic aspects

Soussi selected Maple because it is a comprehensive mathematical software tool with formal computation capacities allowing for accurate solutions to many problems. Additionally, Maple is also a powerful tool for numerical computation with advanced features, including 2-D and 3-D interactive interfaces for graphic visualization, audio and video, he said.

Soussi states that Maple embodies all the qualities required to experiment with mathematics (i.e. to address this subject area in an original, stimulating way that is suitable for discoveries and intuitions). “Maple is easy to learn, and online help, such as permanently-available tutorials, almost exempts you from reading the user guide,” he said.

The following is an example of a math application Soussi developed that illustrates Maple’s capabilities.

Problem
To examine a training sequence for optimization in Maple, Soussi selected 20 varied problems, using the following problem as a guideline: “Find the dimensions of the right circular cylinder of the largest volume that can be inscribed in a sphere of radius 4”.

Soussi selected the proposed structure due to its flexibility, allowing him to explore the various Maple environments. In preparation, he worked around the basic geometric properties of the cylinder (Figure 1), based on voice guidance, to obtain different formulas (volume, surface, etc.)

He worked interactively around the concept of a solid revolution, generated by the rotation of the constant function around the axis. This provided an opportunity for him to address the concept of integral calculus face-to-face, without in-depth consideration (Figure 2).
Soussi then refers users to another application linking both figures of the problem. By interactively approaching the volume of a sphere by cylinders, users can conveniently and efficiently address concepts such as limits and series convergence.

**Problem Solving**
In order to solve the problem, there are several different approaches users can employ. The following are techniques suggested by Soussi in his research.

**Dynamic Animation**
Users can create several 3-D moving figures, which are controlled by the different variables of the problem (cylinder height and radius, in the case of the example problem) (Figure 3). This can improve the spatial perception of these representations.

**Trial and Error**
Soussi presents the possibility of associating the dynamic figures with a value table (Figure 4). He found that by interactively controlling the variables of the problem, the learner is capable of digitally approaching the optimal solution.

**Analytical Development**
Soussi states that thorough analysis of the optimization function(s) - field of definition, derivatives, monotony, remarkable points, curve - is carried out regardless of the form of the function, either by calling the Maple commands - for learners who are familiar with the software - or through the intuitive process of Clickable Math, a concept unique to Maple that simplifies the process for learners who are not as familiar with it. The ‘Tutorials’ tool enables you to autonomously check the various results (Figures 5-A and 5-B).

As an example, Soussi provides the following optimization function, which results from choosing to act on the cylinder radius:

\[ x - 2 \pi x \sqrt{x^2 + 16} \]

He provides the following examples of crossed passages:

\[ f(h) = h + 2 \sqrt{(h-h)^2 + \frac{4}{h}} \]

\[ \text{Verifier analytiquement qu'il s'agit d'un minimum est une tâche ardue. Mais les graphiques obtenus par les élèves nous indiquent qu'il s'agit bien d'un minimum.} \]

\[ f(h) = h + 2 \sqrt{(h-h)^2 + \frac{4}{h}} \]

\[ \text{Notons } f(h), \text{ la longueur totale des tuyaux, avec } h \in [0, \pi] \]

\[ f(h) = h + 2 \sqrt{(h-h)^2 + \frac{4}{h}} \]

\[ \text{Verifier analytiquement qu'il s'agit d'un minimum est une tâche ardue. Mais les graphiques obtenus par les élèves nous indiquent qu'il s'agit bien d'un minimum.} \]
Several alternative approaches that are easy to explore with Maple are possible, Soussi said. Squaring the function, then graphically and analytically checking that its maximum takes place at the same point as the maximum of its initial function is a great example of this approach (Figures 6-A and 6-B).

Visual Synthesis
The graph of a function is often seen as a static object and its link with a phenomenon is not obviously easy to establish for a learner, Soussi said. “The wide array of Maple interactive components allows users to interactively act on the many variables of the problem to simultaneously illustrate several concepts: the tangent (at function level), the sign (at first derivative level) and the concavity (at second derivative level).” This can be seen in Figure 7 below.

But with Maple, the learner is easily able to explore these concepts deeply and optimize their learning.

— Jalal Soussi, High school teacher, Belgium
3Sigma

3Sigma is a company that specializes in automation and robotics. Recently, 3Sigma set out to design Geeros, a customizable, self-balancing gyropode robot. Geeros was designed as an educational robot that students can use to learn about piloting, programming, and modifying robots. The robot’s motion can be controlled using a host computer and the instructions are transmitted instantly to the robot via a wireless connection, providing the students with real-time results in a practical application.

The base of a gyropode robot is an electric vehicle with a platform and two wheels. The robot’s servomechanism is an automatic controller that uses error-sensing negative feedback to improve performance. For Geeros, a proportional-integral-derivative (PID) controller was used because students are usually already familiar with this type of controller. Geeros was built using Arduino, the easy-to-use, open-source electronic prototyping platform. Sensors and actuators can easily be added or replaced in Geeros, making the robot fully customizable.

In designing Geeros, Nicolas Gachadoit, Principle and Chief Engineer at 3Sigma, immediately chose to employ Maplesoft’s MapleSim and Maple to support a model-based system-level design of the robot. As a former employee of Maplesoft, Gachadoit was well aware of the benefits offered by this unique software combination.

MapleSim and Maple provided 3Sigma with distinct advantages over traditional tools. First, the complex mathematical equations used in the design of a gyropode are extremely difficult to manage by hand. Traditionally, the engineer chooses to use a simpler set of equations to represent the model, resulting in less accurate simulations of the behavior. However, using MapleSim and Maple, the model equations are automatically generated and managed by the software. As a result, 3Sigma was able to create a more accurate gyropode model with less effort, giving them higher fidelity simulation results and making it easier for them to test their design.

In addition to automatically generating the equations of motion, MapleSim and Maple allow the engineer to view, analyze, and manipulate those equations. In this case, because they wanted to use a PID controller to control the robot, the engineer transformed the system of non-linear equations into a matrix representation of the linearized equations. This was done quickly and error-free using a single command. The linearized equations remain symbolic, so that the friction, inertia, resistance, and other factors remain as parameters that the engineers, and ultimately the students themselves, can vary and see the resulting changes of behavior.

Due to the advantages provided by Maple and MapleSim, 3Sigma was easily able to design, test, and build the Gyropode robot. “Using the powerful combination of Maple and MapleSim, we were able to create a high-fidelity model that would have been too difficult to develop if we had to perform all the calculations by hand,” says Gachadoit. “As a result, we were able to achieve considerable time savings in the development of our gyropode model, designing it in a fraction of the time normally required for such a complex system, and with much greater accuracy. As well, the symbolic nature of the underlying equations gave us the ability to provide students with the means to easily modify a variety of parameters in the controller and see the change in how the robot actually behaves, which helps them deepen their understanding of the factors going into robotic design.”
Georgia College and State University

Three mathematics professors at Georgia College and State University, Dr. Marcela Chiorescu, Dr. Brandon Samples, and Dr. Darin Mohr, were the winners of a mini STEM educational research grant, acquiring the necessary funds to integrate Maple into several courses at the college. Maple, Maplesoft's engine for advanced math computation, was chosen by these professors to study the effects of technology in the classroom. Their premise was that the growing use of computer algebra systems (CAS) and interactive technology tools such as Maple can hugely impact the learning process. Based on in-depth student feedback about the use of Maple, the result was unanimous: the experiment proved the theory right.

Georgia College and State University is home to roughly 6,000 students. When introducing a new computer algebra tool, Dr. Chiorescu and her colleagues wanted to be sure that their students did not get caught up in attempting to master the software, instead focusing on learning the math concepts. “With its reputation as a user-friendly and intuitive platform for education, Maple stood out as the most sophisticated yet easy-to-use computation software,” said Dr. Chiorescu. “It did not take long for students to become familiar with Maple. Soon enough, it became their go-to tool for solving long and difficult problems.”

Maple worksheets and projects were integrated into three courses at GCSU: Calculus I, Calculus II, and Linear Algebra. The professors chose to integrate Maple by introducing Maple labs. They were administered once every two weeks covering areas in functions, derivatives, Riemann sums, techniques of integration, matrix computations, determinants, eigenvalues, eigenvectors, and many more. Students were instructed to work together in small groups with bi-weekly exercises and assignments.

In his Calculus II Maple labs, Dr. Brandon Samples chose to incorporate Maple in two projects. The first was a modeling project where students explored the computation of surface area and volume for the design of a model. The second project was a real-world application assignment where students, in groups of two or three, were asked to analyze either the repayment of student loans or the purchase of a house. Dr. Samples’ method of teaching combined with the intuitive Maple platform made learning concepts such as inverse functions, techniques of integration, and partial derivatives, much more straightforward. Students reported that Maple’s ability to illustrate a problem with graphs, tables, equations, and words was a huge aid in their learning. Topics that were originally difficult to understand during a lecture were instantly clarified during the Maple tutorials. “It helps you visualize the problems and use them in real life situations,” reported a Calculus II student.

Dr. Chiorescu, who taught Linear Algebra and Calculus II, listed three benefits of using Maple in her classroom: “Maple increased focus on conceptual knowledge, provided connections between multiple representations, and helped to develop advanced mathematical thinking.” A Linear Algebra student of Dr. Chiorescu’s reported that she enjoyed Maple because it simplified complex equations and helped her from getting lost in calculations.

After using Maple in their classrooms, the teachers at Georgia College reported that they not only enjoyed the engaging new way to teach math in their classrooms, but also felt confident that Maple prepared students for future careers in mathematics with its real world applications. Students also learned skills that they were surprised to find were applicable to other classes. “One of the most powerful features of Maple is its ability to evaluate expressions and find solutions to problems that would take an enormous amount of time to do by hand,” said Dr. Chiorescu. Maple also trained students to discover errors and then follow the proper corrective procedures, ultimately enhancing reflection on past work and determining how to avoid similar problems in the future. “Although we had some concerns in the beginning about introducing this new approach in the classroom, Maple did not slow or hinder the students’ grasp of the concepts. In fact, Maple helped to transform the standard chalkboard method of teaching math.”

The professors did surveys at the end of each course, asking students to evaluate their experiences with Maple. “Maple proved very popular with the students. Eighty-five percent reported that it was a substantial aid in their learning and believe it will be very useful in their future careers,” said Dr. Chiorescu. However, it wasn’t just the students that reaped the benefits. The professors found that their own teaching practices were improved through the introduction of Maple. “Designing and preparing for Maple activities enhanced our perspectives for improving the usage of technology in the classroom and helped us to truly understand what it takes to create projects that deeply engage students in their learning,” said Dr. Chiorescu. “A great collaboration was developed during this project and it is one that we hope will be a foundation for future successful projects. We are certainly going to continue with our use of Maple at Georgia College.”
Engineering Professor Uses MapleSim to Introduce More Exploratory Methods of Teaching

Dr. James Andrew Smith, Electrical and Biomedical engineering professor at Ryerson University, Toronto, is very excited about experimental changes he made to his teaching approach in class. He introduced tools and methods that help students generate knowledge through interaction, explore the subject better, and create a more in-depth understanding of the subject. He calls this an “inductive approach” to learning rather than the traditional “deductive approach.” He considers MapleSim – the system level modeling and simulation tool from Maplesoft - as a key inductive learning tool, very different from deductive learning tools.

Dr. Smith introduced MapleSim in the third-year Electrical Engineering program, in classes focusing on an introduction to robotics and microsystems. One goal of these classes is to familiarize students with tools for analysis, simulation, visualization and design. He used MapleSim to see how an inductive approach to learning can improve student comprehension. “An inductive approach allows students to explore a system, and derive equations from the behaviors they observe in the system,” explained Dr. Smith. “Contrast this with the deductive approach, which is the traditional way of teaching, that involves giving students a set of equations and letting them deduce what it means and what kind of behavior it demonstrates. The inductive approach enables knowledge generation through interaction and pushes the students to explore further.”

According to Dr. Smith, traditional tools have their place, but they don’t let the students see under the hood, which is an impediment to learning. “What makes MapleSim different from others is that students can ask MapleSim for underlying equations and interact with it in different scenarios. This openness is very unlike other tools in the market. With MapleSim, students can easily connect the analytic models in textbooks to the numeric solutions that result from the simulation. It also has a very intuitive user interface which makes it easy for students to explore the software and arrive at new conclusions.”

As an illustration, Dr. Smith provides a simple topic dealt with in the third-year engineering program. A very fundamental concept all students deal with in the electrical engineering class is the subject of operational amplifiers. It is important for students to tie in how an operational amplifier modulates a signal or how it amplifies/attenuates a signal, and any simulation package used has to be able to facilitate a very clear understanding of this concept. Traditionally, the instructor would refer to a standard text book like “The Art of Electronics” and give students the golden rules of operational amplifiers and tell them how current goes into certain ports and not other ports and why voltages should be of a particular value. The students are then asked to solve the circuits by hand. “There is a lot of potential for error here,” said Dr. Smith. “It is a lot to ask of the students, especially if they haven’t had any experience with electronics, and it is difficult for them to figure it out in a short amount of time.”

Alternatively, Dr. Smith’s inductive approach gives them MapleSim. He gets the students to start by drawing the schematic, and then simulate with MapleSim. He then makes them extract the underlying equations in MapleSim, explore it using different scenarios, and analyze the equations to derive conclusions. “The best part of this for students is that they can match it with what they are seeing in their textbooks,” said Dr. Smith. “The simulation process they go through is the same as they see in the textbook. It reinforces what they read and provides a nice link between what they do on the computer and what they see in the textbook.”

In addition, Dr. Smith takes the use of MapleSim further by extending basic examples in the textbook to show students more useful real life illustrations. This expands the scope for students and they are encouraged to think beyond the limited span of a particular problem. Because of MapleSim’s system-level approach to multi-domain systems, students often extend a problem in electrical engineering to what they learn in their mechanical engineering class or instrumentation class. “To me this is the real power of MapleSim,” added Dr. Smith. “Because of its possibilities in multi-domain modeling, it beats other software tools that are similar. It provides students with a familiar environment to work with, and helps them relate problems and examples in different fields to get a comprehensive view.”

Dr. Smith is convinced that MapleSim is a critical tool in an engineering instructor’s toolkit because it facilitates inductive learning, which he believes is the paradigm of the future.
Mathematics is more than a series of numbers, symbols and equations. It is at the root of many concepts that we encounter on a regular basis. Lina Wu, a professor at Borough of Manhattan Community College, The City University of New York (BMCC/CUNY), wanted to find a creative way to teach calculus and show students that math is not just numbers, but is fundamental to many ideas and principles in the universe. Wu chose to focus on art, challenging her students to identify mathematical elements in various pieces of art. Using Maple, she developed a method for teaching mathematics that tied in visual images.

While Wu was teaching at the University of Toledo, the math department introduced Maple to its faculty members. Maple has played an important role in her teaching and research since. In addition to her work as a professor, Wu is completing educational research on her teaching pedagogy of using a Project-Based Learning method that combines math, art and Maple technology. Maple’s visualization features, animated graphing tools and symbolic and numeric calculation tools make it ideal for Wu’s unique teaching approach. “So far I have created 6 Maple artwork projects in calculus courses,” she said. “These and other research projects have taught students how to apply their knowledge of math and Maple to create artwork.”

Wu, along with several colleagues, conducted a study on the value of using artwork to teach calculus. The study, published in the International Journal of Applied Research, was motivated by math anxiety in students, as well as various limitations to the current method of testing, specifically multiple choice tests. Wu wanted to design a mathematics curriculum to help students better understand mathematics and gain the ability to apply it to real-life situations. The study found that math concepts, such as numbers, shapes, patterns, groups and symbols, can often be seen in artwork, which makes it an ideal medium to explore mathematics. Using images to break up the abstraction of math subjects also helps alleviate students’ anxiety towards the subject.

Wu believes that visualization through artwork enhances students’ intuitive understanding of calculus concepts and theories. In Wu’s calculus class, students use their knowledge of various concepts to create art diagrams using Maple, which in turn helps improve their grasp of the materials. They visualize concepts through their designs and gain perspective on the impact of changing parameters.

Wu has her students view art at museums in New York City and identify pieces that may contain elements rooted in or related to mathematics. When students identify pieces, they then must explain how the artist applied math in their artwork. It’s not easy to find math in art, but it’s a fun challenge for students to get them thinking about math beyond the numbers, Wu said. She recently decided to take the idea one step further. “I thought it would be interesting to have the students create their own artwork using their knowledge of mathematics,” she said.

As a result of Wu’s course, students spend a significant amount of time and effort using math to create art, leading to better understanding of math concepts. Maple is valuable in this regard, as it allows students to visualize their artwork and make changes to their designs quickly. Students are able to apply all they have learned in math to produce a masterpiece of artwork they can be proud of. “There was no doubt in my mind that Maple would be the ideal technological tool for students to create images using math, she said. “The dynamic and interactive applications in Maple make it easy for students to communicate their math ideas through computerized programs. Visualization tools in Maple enable students to see how changes in the math impact their artwork.”

During these projects, Wu encourages her students to interact with each other, share ideas and have open discussions in the classroom. This provides Wu with an opportunity to engage with the students about project ideas and execution, how complex ideas use math and answer questions about Maple itself. Wu’s research into her teaching method has been published in peer-reviewed mathematics journals and the artwork her students have produced in class has been presented at annual math conferences such as the AMS-MAA Joint Mathematical Meetings and MathFest. Students who participated in Wu’s pilot courses provided very positive feedback. They were able to learn calculus in a non-traditional way and, after completing the projects, they were impressed with the finished product. “They see themselves as artists and mathematicians, and are proud of their achievements,” Wu said. “My project-based teaching approach has ignited students’ desire to learn math. They use their math knowledge along with Maple to produce impressive artwork. With the many advantages that come with using Maple, it has become an important technological tool in my calculus teaching.”
Educators in high schools around the world have discovered that Maple helps them give their students a head start in mathematics education. As a high school math teacher, Calvin Armstrong of Appleby College, a private high school in Oakville, Ontario, Canada, gives his students an early start in advanced mathematics by introducing them to tools used in university and industry. He wants his students to push boundaries and excel in their quest for knowledge. It is a philosophy that is embraced by Appleby College as a whole, making it known across Canada for academic excellence.

Calvin wants his students to see beyond theories in the textbooks, and consider implications for their future studies and work. It is with this intention that Calvin introduced Maplesoft’s technical computing software, Maple, to high school students.

Here is what Calvin says about his students’ use of Maple:

"Maple lets students push boundaries that they couldn’t with other tools. It incorporates all the aspects of their mathematical understanding, from algebra to geometry and calculus. It takes all of their formal understanding from textbooks, and puts it into an algebraic context or a graphical context. Maple really is an environment for students to play mathematically. However, using Maple is not limited to mathematics; it can also be used in any stream of science or technical course. It is a tool that will start them in Grade 9 and last them well into university.

"We realized the potential in Maple to start students earlier - it is simple to learn, but powerful enough to let students grasp the concept."

— Calvin Armstrong, Appleby College

"Initially, at Appleby, we were using Maple in Grade 12 calculus class, when students are almost heading out into university, becoming familiar with advanced mathematics. We realized the potential in Maple to start students earlier - it is simple to learn, but powerful enough to let students grasp the concept. So we started them on Maple in Grade 9 mathematics. Linear systems are not only heavily algebraic, but they also have graphical components. We started using Maple to teach the idea of substitution, leading the students through the algebraic process. We were very surprised to observe that not only did they grasp the idea of 2x2, but instinctively considered the possibility of having three variables, and figured out how to do a 3x3. Students advanced their own learning by asking themselves the question, ‘what next?’

"Very often we talk about math being a search for patterns. We as teachers want students to explore how a change in variable or value affects a given situation. Doing it by hand is extremely tedious, and the search for pattern overwhelms the pattern recognition itself. Graphing calculators can be clumsy and not very efficient. Doing animations with Maple gives students quick values, allows them to nicely move values on sliders, and provides animation. It can also be incorporated into one document that can be distributed to other students, or projected onto a whiteboard while the students explain the animation in progress. The document can be shared easily between students and the teacher. In fact, these documents can be shared with other students and faculty around the world, increasing chances of collaborative learning.

"Maple is also a great companion for the math teacher. It provides the teacher great flexibility in the development of assignments and tests. It gives them flexibility in the creation of the graph, the ability to zoom in and out by changing parameters, and the means to develop a whole series of questions so that there is differentiation in the classroom. Maple really helps the teacher develop questions and lessons in a meaningful way without spending too much time.

"Students quickly realize that Maple is a sophisticated tool with a breadth of options to explore. It helps students understand that mathematics is a growing idea, far beyond the text books. Maple helps in expanding the students’ understanding of mathematics, and helps them realize it is not limited to what they are learning now. The fact that this software helps to explore and understand the depth and breadth of mathematics is a huge advantage for Maple."
Professor Ranferi Gutierrez has long been a proponent of online educational solutions as a supplement to, and possible replacement for, more traditional teaching methods. When giving lectures at the Universidad Rafael Landivar in Guatemala, he uses technology tools like Maple to bring his classes to life, to keep students engaged and to offer them an easy way to understand complex mathematical concepts.

Though access to online educational tools was limited in Gutierrez’s home country when he was a student, he became interested in computer simulation programs through his studies in mathematics and physics. “Utilizing computers as an educational tool is still a relatively new idea in Guatemala,” Gutierrez said. “We hardly had one computer at the University de San Carlos de Guatemala, where I completed my undergraduate studies.”

When he started teaching a Calculus course in vector analysis at the Universidad Rafael Landivar in 2001, Gutierrez began developing his first lessons using limited resources, while trying to find advanced technology to help in teaching. He began looking for a new software tool that would allow him to solve simple problems like drawing quadratic surfaces, to replace the black and white textbook photocopies he was using. One of his students who was using Maple V introduced Gutierrez to the software. “I asked him to create some quadratic surfaces, from different angles, and I printed them on acetate so I could use them in my classes,” Gutierrez said. “It worked really well, and I became a fan of Maple, although at the time, I was still not aware of Maple’s full potential. As I gained experience with Maple’s full set of features, I knew it would be of great benefit to my students.”

Gutierrez went to university officials and convinced them to purchase Maple licenses for students. It was then that he began to further experiment with Maple and understand its full capabilities. “I started to create course material in Maple where I laid out step-by-step processes for different mathematical concepts such as constructing 2-D and 3-D graphs, calculating integrals and derivatives, or solving differential equations,” he said. “We even invested in labs so students could experiment with the software during their free time.”

Maple was installed on university computers, but implementing it into courses was initially a difficult process due to hesitation from teachers who were accustomed to traditional teaching methods. Resistance from teachers was partly due to a fear of technology, and partly because they didn’t want to disrupt traditional ways of teaching. “Many belong to the old guard, preferring to use chalk on a blackboard in their teaching of mathematics,” Gutierrez said. “They did not understand how a computer can be used as a teaching tool, as well as a tool for research and investigation. This is due in part due to the fact that emphasis has traditionally been on electronic sheets or word processors than math software.”

Many students were excited about Maple because they could now manipulate figures that were previously static in textbooks. 
— Professor Ranferi Gutierrez, Universidad Rafael Landivar

Gutierrez also encountered resistance from some students. “Some students were fearful at first, despite belonging to a generation that regularly uses computers, but they eventually opened up to the idea,” he said. “Students only used computers for gaming or social media. The incentive to use the technology was there; it simply needed to be redirected. Some routinely look to the internet for support and assistance with problem solving, which made it easier to sell them on the idea of using computer-based teaching tools.”

To get his students familiar with Maple, and to make the transition to technology easier, Gutierrez created Maple-based assignments for his course. As the students got to know Maple and its easy user interface they came to embrace the new tool. “The possibility of using embedded components with a drag and drop approach, and not having to worry about programming, got the students to open up more to Maple,” he said. “For example, they could easily adjust parameters through sliders, buttons, etc. and immediately observe what happens when these parameters are changed. Maple made it very easy for them to do such operations.”

When preparing his lessons, Gutierrez incorporates different teaching methods to address the preferences of all his students, and to further ease the transition to online education tools. One example is a lesson on 3-D coordinate systems. In the first lecture of the course, he creates a 3-D coordinate system using metal rods, and uses small balls of foam to teach students to locate the points in that model and become familiar with the 3-D system. Then he uses Maple to illustrate the 3-D system in a computer and help students visualize the concept. “The
display is much better with Maple, and they don’t have to worry about programming like in some other similar software,” he said.

One of the features Gutierrez most appreciates about Maple is the ease with which he is able to create various applications, allowing him to fully concentrate on areas where students face difficulty. He also cited Maple’s easy-to-use interface as a key factor behind his decision to use it. “I like the ease with which you can change colors, line styles, add titles, and more.” He said.

Gutierrez is keen to see students succeed using technology tools, and he strives to make it as easy for students as possible. He prepares study guides for certain subjects that students can take home to further practice problems. He has also created tutorial videos with Maple, so students can better understand the material at their own pace. “The students use these guides and videos at home and then we do short written tests to make sure they have used the resources and have understood the material,” he said. “I like it that they don’t require anything but the Maple Player to do that.”

He has tried other software tools, but found Maple to be a more convenient option. “I used Mathematica for a semester, but eventually I gave it up,” he said. “Maple’s programming was very clear and logical. I found the programming language to be far less complicated than the alternatives.”

Over the years Maple has become more accepted at his university, thanks to Gutierrez’s efforts. His colleagues recognize that Maple is much more efficient than more traditional methods. Maple is now a permanent part of many courses, though Gutierrez is still working with his fellow instructors to help them overcome any remaining hesitation and implement it on a wider scale.

In addition to his teaching, Gutierrez has completed research projects and been involved with various physics and mathematics committees. He was a member of the USAC-UTRECHT Committee on Media Education, a collaboration between the Universidad de San Carlos de Guatemala and the Utrecht University in the Netherlands to improve the teaching of physics in Guatemala. He has also served as the Mathematics Coordinator for the Faculty of Engineering at Universidad Rafael Landivar. Gutierrez feels opportunities are still limited for professors in his home country, and he works hard to improve the quality of education and introduce new, more effective teaching methods.

“The ease of simply dragging and dropping the different elements where you want, as well as the ability to effortlessly modify parameters, make Maple an ideal teaching tool.”

— Professor Ranferi Gutierrez, Universidad Rafael Landivar
In a world where we are introduced to new technologies on a regular basis, there are some tools that are able to stand the test of time. Maple began as a research project at the University of Waterloo in the 1980s, and has continually evolved and adapted to meet the unique and ever-changing needs of institutions, educators and students for STEM programs. Darrell Pepper, a professor at the University of Nevada, Las Vegas (UNLV), has been using Maple since its early editions and continues to regularly incorporate it into his teaching. He views Maple as a valuable and powerful tool for engaging students and making learning more interesting.

Pepper was introduced to Maple when it was first developed at the University of Waterloo. He became interested in its capabilities and potential and started using it in his research. He has been using it since, preferring Maple’s power and ease of use to other tools. Even after all this time, with all the features and functionalities added over the years, there is still so much to discover in Maple, Pepper said. Pepper has been teaching numerical methods for engineers for many years, using multiple tools in the process. When he first introduced Maple in his class, students quickly realized the power of the software and the great benefit it offered them. He later introduced examples from Maple in his fluid mechanics classes, and finite element and CFD classes. “I like Maple’s intuitive ease of input and quick response in solving many of my mathematical issues,” he said. “The depth and sophistication of Maple provides me with the feeling of having a mathematical expert that I can call upon at any time. I don’t get that feeling with many of the other math software packages on the market.”

Pepper’s students have shown great enthusiasm towards Maple due to its ease of use and efficiency of cost. The students are also drawn to Maple’s reliable ability in providing accurate results, identifying errors and providing quick solutions and feedback. “Students appreciate the ability to produce a solution and immediately see the effects of changing parameters, Pepper said, “They are always amazed at the few lines of coding required to setup and solve a problem.”

“Maple has allowed me to quickly develop and test concepts and ideas without the need for extensive programming and debugging.”

— Professor Darrell Pepper, University of Nevada Las Vegas
Pepper uses Maple to layout and test concepts and algorithms. He and his students convert Maple models to FORTRAN-based algorithms that run on a massive supercomputer at UNLV. In one instance, they were able to develop a microscale dispersion model that covered the start of the fracking process in oil drilling, eventually expanding the process (using fractured finite element techniques to establish cracking pathways) that reached many meters in scale. They have also used Maple to develop air pollution models that are being developed for use by emergency response personnel in the event of an atmospheric release or accident.

In another project, Pepper and his students used Maple to simulate ideal airflow over a Frisbee, later updating the algorithm to include a solution of the Navier-Stokes equations to model viscous incompressible flow over the Frisbee. They then built the world’s largest Frisbee – 10 feet in diameter – using composite material that was later thrown by one of his mechanical engineering students. “We’ve used Maple in many unique and interesting ways,” Pepper said. “I’m amazed at Maple’s progression over the years. I originally used software called TK Solver and thought it was a clever idea to utilize these types of packages. I was elated when Maple appeared some years later.”

Maple is a reliable tool that Pepper strongly recommends to others. He regularly uses Maple with both his undergraduate and graduate classes, and finds its power and features superior to similar tools on the market. “Maple resources provide a lot of support. I like the applications and the website for users to examine and download content,” he said. “And I particularly find value in Maple’s content sharing, such as the access to example problems and applications other users have uploaded to the Maple website. It is a highly-beneficial tool for me in my teaching.”

Pepper’s experience with Maple has motivated him to write two books on the finite element method. For the most recent book, he used Maple to illustrate concepts and short algorithms, and included code listings within the text using Maple and MATLAB. In Pepper’s experience, Maple is a more beneficial tool than MATLAB. “I think the big difference is the succinctness in Maple versus MATLAB,” he said. “We just recently developed a 2-D FEM recursion relation that uses the SIP method to solve transport equations – we no longer need a global matrix solver – and used Maple to verify the concept. I also used Maple to verify the meshless method.”

Pepper found Maple to be a useful tool from the moment he began using it and that hasn’t changed over the long number of years since his first introduction to the tool. “I have used other tools in the past, but find Maple to be much friendlier,” he said. “Maple’s flexibility to handle many different kinds of problems and its ease of use - made easier with the latest versions - remain its quality features. Its mathematical prowess seems to get better with each new release.”

Even with all the updates over the years, Maple hasn’t strayed from the core features that made it valuable to begin with, Pepper concluded. “I like the fact that I haven’t gotten lost with the latest bells and whistles and that the package still delivers.”
The University of Manchester Uses MapleSim in Robotics and Control Systems Courses

University of Manchester

The University of Manchester, the largest single-site university in the UK, has a reputation for producing some of the world’s greatest engineering and mathematical minds. Twenty-five Nobel Prize winners have either worked or studied at the University.

Dr. Joaquin Carrasco, Professor of Control Systems at the University’s School of Electrical and Electronic Engineering, has taught various Control Systems courses to Master’s students in the Master of Science in Advanced Control and Systems Engineering program for the past six years. He has recently incorporated Maplesoft’s MapleSim and the MapleSim CAD Toolbox into his Robotics courses. With the MapleSim CAD Toolbox, students can see how their mechanical CAD models behave as part of a larger, multidomain system. The students can easily apply MapleSim’s advanced analysis tools to improve their designs. This toolbox makes it easy to import CAD models into MapleSim, automatically capturing the kinematic and dynamic properties of the model components. Using the MapleSim CAD Toolbox, Dr. Carrasco’s students have modeled several complex devices including a 3-D printer, a haptic robotic manipulator and a pick-and-place robot.

In the University’s renowned Bachelor of Engineering in Mechatronic Engineering program, students learn about the design and implementation of intelligent mechatronic systems. Recently, Dr. Carrasco began teaching Applied Mechanics for Industrial Robotics to second year students taking this program. Based on his previous experience with Maplesoft technology, he decided to enhance the Robotics classroom experience with the introduction of MapleSim, which offers students a rich engineering environment to develop high-fidelity models. According to Dr. Carrasco, “3-D visualization is a priority for my Robotics class and MapleSim is the best 3-D visualization tool available.”

Using MapleSim, students are able to visualize the concepts they are learning. The acausal multidomain modeling environment of MapleSim provides students with an intuitive and natural avenue for modeling. MapleSim uses symbolic and numeric computing techniques to yield accurate models that depict the behavior of the system. MapleSim’s component libraries allow the students to easily drag and drop ready-made components into the workspace. One way Dr. Carrasco uses MapleSim in the classroom is to provide the students with a MapleSim robotic model and have the students find the equations of motion. MapleSim’s easy-to-use interactive approach allows students to visualize the robot and manipulate the underlying mathematical equations.

Within MapleSim there is a learning module: The Forward Kinematics of Serial Manipulators. Introducing the Denavit-Hartenberg Convention, the focus of the module is to obtain the position and orientation of the end-effector of a robotic manipulator. Useful for calculating the forward and inverse kinematics, the D-H Convention describes the motions of a series of joints (revolute and prismatic) with respect to a reference frame. Dr. Carrasco noted, “The concept of D-H parameters is very difficult to explain to undergraduate students. Using MapleSim, the mathematics comes alive and the students are able to easily visualize the concept.” Unlike other software packages, learning modules are free with the purchase of MapleSim.

Dr. Carrasco also uses the MapleSim Model Gallery in his Robotics class. The gallery contains many robotics examples demonstrating varying degrees of complexity. The gallery contains models from a Simple Inverse Kinematic Problem to a more advanced model of a KUKA™ Robot. This model is based on a robot from KUKA Robotics, one of the world’s leading manufacturers of robotic systems. In the KUKA robot model from the MapleSim Model Gallery, the robot mimics the handwriting of any word the user selects. The example in the Model Gallery shows the robot writing the word Maple. Using the existing model, Dr. Carrasco asks the students to program the robot to write their own names. The students can use parameter sweeps to change the model, obtain the revised data and understand the immediate ramifications of any parameter change on the model.

Often, there is a disconnect between the practical applications taught in the classroom and the applications students encounter in the real-world. MapleSim bridges this gap by allowing students to visualize and experiment with real-world examples, such as the KUKA robot model, that expand on the knowledge gained in the classroom. “MapleSim really helped me learn how to best teach robotics to my students. It helped me understand how to explain robotics in a real-world context,” said Dr. Carrasco. “Unlike control design, where mathematical manipulation is sometimes difficult to visualize, in robotic design, mathematical manipulation changes the movement of the robot. MapleSim makes it easy for the students to visualize any changes. In my opinion, MapleSim is simply the best software package available to teach the principles of robotics.”

The students in Dr. Carrasco’s second-year Robotics class have benefited so much from MapleSim that Dr. Carrasco plans to begin using MapleSim for third-year robotics students in the coming term.
Georgia College Professor Uses Maple to Prepare Students for Life Beyond School

When it comes to education, working with the right technology is not only essential for effective learning, but it can also provide students with valuable tools to set them up for future success. Choosing the right teaching methods and assets can improve understanding and confidence, better preparing students for future education and career paths. This is especially true in science, technology, engineering and mathematics (STEM) courses, where students deal with complex subject matter. Bruce Scranton, a professor at Emmanuel College in Georgia, adopted Maple to better engage his students and equip them for long-term success.

Scranton originally spent 30 years working in the professional world, serving in a variety of roles relating to mathematics research, algorithm development, problem solving, sales and technical support. He then decided to pursue his passion for teaching, and became a faculty member at Emmanuel College more than a decade ago. At the time, Emmanuel had a course in computer programming, which Scranton felt was a valuable course for mathematics majors. “Computers are excellent tools we can use to help solve math problems,” he said. “They force people to be precise and detailed, and they enforce a level of discipline.”

Reviewing the math programming curriculum for the course, Scranton wasn’t pleased with what he saw. He didn’t want to have to teach his students a new language, with the necessary expenditure of significant, valuable time on syntax. There are more important things mathematicians should be learning, he believed. “There are big concepts in programming students should know about,” he said. “Our goal is to help them think about and know how to understand each problem, design a solution for it, test and verify that solution, and document the process.”

Based on his time working in industry, Scranton was convinced that mathematicians may become some of the best programmers and systems engineers due to their natural ability to think things through from start to finish, and be very deliberate about the process they follow. This led him to Maple, a tool designed by mathematicians for mathematicians. As department chair he took the initiative to develop a new course, Mathematical Solutions Technology, which he split into two parts. In the first half of the course, Scranton had his students working with Excel, to learn more about its various features, including all of the mathematical functions, beyond inserting and adding numbers. In the second half of the course, he introduced his students to Maple to see what they could do with a real math tool developed by mathematicians to specifically meet the needs of STEM courses. “It totally blew their mind,” Scranton said.

For Scranton, Maple also minimized the burden of having to
teach his students various programming commands and syntax, as the software features a natural mathematical syntax that was easy to use. The time saved allowed Scranton to address some of the more fundamental aspects of programming. “Since I didn’t have to spend the same effort on programming, the students and I were able to spend more time on communication and discussing why various functions and programming concepts were important,” he said. “I place a lot of emphasis on communication in my courses.”

After working really hard through Calculus courses using more traditional methods, students found out one could just enter expressions and have Maple calculate the answers. They had a lot of fun with it.

— Professor Bruce Scranton, Emmanuel College

Daniel LeCroy, a former student at Emmanuel who is now a professor at the college, was introduced to Maple in Scranton’s class. He was instantly hooked by how easy Maple was to use and the convenience it offered. He continued to use it in other courses and uses it as a teaching tool today. LeCroy attributes Maple to helping him better understand key concepts and said it was of great benefit to him as a student. “From seeing planes in linear algebra to visualizing Newton’s method in Calculus, the visual processing that Maple provided made my understanding very clear,” he said.

Later on, during his research, LeCroy developed even greater appreciation for Maple’s power and features. “I truly began to appreciate the speed at which Maple ran, doing nearly three-hundred calculations, along with derivatives, and comparing them all with a simple ‘do’ command that had finished in the time it would’ve taken me to write the first of the three-hundred equations! It made me realize just how powerful a tool I had,” he said. “For me, Maple has a much more user-friendly interface than other math software. The learning curve is also not as steep, due to Maple’s resources and in-depth user guide.”

As a teacher, he values Maple’s visualization tools that allow him to create accurate and appealing graphs that better engage his students during lessons. “I also use some of the slider features in the lessons to show them how transformations work. It is great for them to see the original graph along with this new one that was being manipulated before their eyes,” he said. “I have used Maple many times in both high school and college settings, and received great response from my students.”

Over the years Scranton’s students have also responded well to Maple and are often amazed at its capabilities. “It is way beyond what I saw when I first started using Maple,” he said. “The amount of thought and time students put into understanding solutions, being able to validate that they have a good answer, catching themselves in mistakes and fixing them, it is much better in Maple than with paper and pencil.”

The ultimate goal from Scranton’s perspective is to prepare students for the real world. Teaching in a small county in Northeast Georgia, where most kids haven’t ventured far from the county, Maple is vital in setting students up for success in college and beyond, Scranton said. “I receive a lot of great feedback from my students, and I think my background has helped to give me a unique perspective,” he said. “I want to be able to give them a different view of the world and strong preparation; Maple has enabled me to do that. Some of these students have gone on to big colleges and beyond, and they talk to me about how they felt like the work we did uniquely prepared them.”
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Maplesoft has provided mathematics-based software solutions to educators and researchers in science, technology, engineering, and mathematics (STEM) fields for over 30 years. Maplesoft's flagship product, Maple, combines the world's most powerful mathematics engine with an interface that makes it extremely easy to analyze, explore, visualize, and solve mathematical problems. Maplesoft products and services are used by more than 8000 educational institutions, research labs, and companies, in over 90 countries. In 2018, Maplesoft spun off its online education product line into a separate corporation, DigitalEd.

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