Mathematical Sciences
UNIVERSITY OF MONTANA FALL 2014

iPads in the Classroom

By Grant Swicegood

When people hear about iPads in the classroom, they often picture a scene out of science fiction. After all, be it Ender's Game, Star Trek, or Futurama, the classroom of the future always seems to involve the extensive use of technology. Perhaps inspired in part by such depictions, iPads and other tablets are being aggressively rolled out

Star Trek's depiction of the future classroom
©Paramount Pictures and/or CBS Studios; more info at http://en.memory-alpha.org/wiki/File:DS9_school.jpg

to many classrooms at all age levels. After all, it's the 21st century and the mathematics classroom should reflect it. No doubt, many people think that such technology will easily fix whatever learning difficulties students are experiencing today.

Of course, the hope that technology can miraculously "fix" mathematics learning is not new. The current situation is very reminiscent of the push for personal computers in the classroom throughout the 1990s. Anyone who has seen unused computers in classrooms

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UM Students Investigate the Elusive Relationship Between Topology and Geometry

By Eric Chesebro

In 1982, William Thurston won the Fields medal for making strong connections between 3-dimensional spaces and geometry. In particular, he proved his "Geometrization Theorem for Haken Manifolds" and made his "Geometrization Conjecture." Roughly, his theorem shows that a very large and important class of three- dimensional spaces can be cut, in a natural way, into pieces with very nice geometric structures. His conjecture suggested that this was true for all 3-dimensional "manifolds." Grigori Perelman won the Fields medal in 2006 for proving Thurston's conjecture.

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Brian Steele Wins IBM Award

By Dave Patterson

About three years ago, local technology businesses reached out to the University of Montana to train students in the use of IBM's Infosphere Streams software, which is used for processing and analyzing very large volumes of streaming data. The Business School started developing a course but soon realized they needed someone with statistical expertise to help teach it. Brian Steele, Associate Professor in the Department of Mathematical Sciences, volunteered for the job and quickly became immersed in the statistical and programming aspects of "big data". He developed additional courses over the last two years in the Math Department that have become part of a Big Data certificate program at UM. For his efforts, Brian was recently awarded a 2014 IBM Big Data Faculty Award. The

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Inside

Notes from the Chair

By Leonid Kalachev

I want to start this column with an update on some recent developments within the Department of Mathematical Sciences. Two permanent faculty members, George McRae and Jim Hirstein, have announced their retirement plans in the fall of this year. In the current budget environment the usual procedure is to fill in the positions with the new hires after a one, two or three year delay. We were very fortunate that the UM administration, and in particular, Dean Chris Comer and Provost Perry Brown, have carefully weighted and understood the difficult situation with the teaching personnel in our department in view of some faculty members and lecturers being on leave, some retiring and others applying for sabbaticals and exchanges, and allowed us to start a search for a new permanent position in the area of Mathematics Education. While the job market situation in this area of research is challenging, we will do our best to hire the best person available or, at least, to hire the most qualified candidate for a temporary position using the pool of applicants that our job announcement will attract.

Another important development is related to the process of selecting a new department chair whose duties will begin on July 1, 2015. We have an outstanding candidate for this position, Professor Emily Stone. The department has supported this nomination; corresponding documentation was related to the Dean of the College of Humanities and Sciences. The final decision on the new chair appointment will be made by the Provost sometime in the spring semester of 2015.

Several changes have happened to our departmental web site. It now satisfies accessibility requirements, i.e., it can now be used by the students and general population with sight and hearing impairments. Starting in January of 2015 the personal web pages of the faculty members and lecturers will also become compliant with accessibility requirements.

The department continues to be extremely active in teaching, scholarship / research and service. During the faculty evaluation process that took place this fall semester nine faculty members were nominated for merit awards. I think that each of them deserves a merit! I applaud their commitment to their profession, to students, and to service to the society on the local, national and international levels.

The Big Data activities pioneered in our department by Brian Steele and other faculty members a number of years ago are now taking more concrete shape with the pending approval of the Big Data Certificate and the assignment of permanent numbers to the Big Data related courses. The number of job offerings in this area, as well as in STEM disciplines in general, is constantly growing and the employers have difficulty finding graduates who could fill the available positions. In the fall of 2014 several large hi-tech companies contacted our department with requests of information about this program, possible pilot projects, and offers of potential internships. In December of 2014, Hewlett Packard sent recruiters to interview our students taking Big Data classes for a position at Plano, TX (I think that it is noteworthy that they came from Texas to look for qualified employees in Montana!). To me this shows that our efforts in developing expertise and teaching courses in this area are paying off, especially in making the University of Montana known as a place for data analytics.

As always, I would like to take this opportunity to wholeheartedly thank our donors for their continuous support! Your generous gifts allow us to fund fellowships and scholarships for our graduate and undergraduate students, pay for student travel to professional meetings, invite inspirational speakers to our colloquium and do many other exciting research and education related things that otherwise would not have been possible. Thank you very much! We look forward to keeping in touch with you and to informing you about our successes as well as about potential difficulties (related to running the program under the condition of shrinking budgets) for the years to come.

Let me end this column by wishing everyone all the best for the Holiday Season! Have a very Happy New Year!

$(MT)^2$ Grant

By Jen Kacmarcik

This summer the University of Montana received a 5-year grant from the National Science Foundation's Division for Undergraduate Education to launch a new project, $(MT)^2$. This grant brings more than $600,000 to the University, almost all of which will go to scholarships and fellowships for talented students in the mathematical sciences who have high financial need and who come from groups that have been traditionally underrepresented in the mathematical sciences such as women, minorities, and first-generation college students.

The $(MT)^2$ program is based on the premise that a strong STEM (Science, Technology, Engineering, and Mathematics) workforce that can successfully solve complex problems must include all segments of our population. The program seeks to improve undergraduate and graduate mathematics education by providing a learning environment that gives students the financial means, professional guidance, and community support they need to pursue degrees in the mathematical sciences. Our goal is to develop a diverse well-educated student body.

$(MT)^2$ provides

- scholarships of up to $9000/year (depending on need) for talented undergraduate math majors
- fellowships of $10,000/year for talented graduate students
- summer programs for students in their first two years of college aimed at drawing students into the major by showing them interesting real world problems from all areas of mathematics
- faculty and peer mentors to participants at all levels
- opportunities to work with faculty on research projects

Each $(MT)^2$ Undergraduate Scholar and each $(MT)^2$ Graduate Fellow can receive two years of support from the program. Each year we hope to have a cohort of 5 new Scholars and 2 new Fellows. For more information about our program, including how to apply, visit our website: http://hs.umt.edu/mtsquared.

Associate Professor Jen Kacmarcik is the Principal Investigator for the $(MT)^2$ grant. She is also the Associate Chair for the Math Department's Graduate Program.

$(MT)^2$ Graduate Fellows

By Jen Kacmarcik

We are delighted to introduce to you the first two Graduate Fellows in our program: Ricela Feliciano-Semidei and Roger Mad Plume.

Ricela is a new student in our Ph.D. program. She was born in Texas and grew up in Puerto Rico. She earned a B.S. in Pure Mathematics and an M.S. in Statistics from the University of Puerto Rico. She also earned a secondary teaching license. For a year before joining us she was an Instructor of Mathematics at the University of Puerto Rico, teaching precalculus and applied and elementary statistics. She intends to focus on math education while here, perhaps doing her thesis work in statistics education, which is a new and very active field today. She would love to spend her career as a Professor of Math Education in Puerto Rico, perhaps helping to establish a Master's program in Math Education at her former institution.

Roger Mad Plume is a new student in our M.A. program. He earned a B.S. from Montana Tech in 2010. From August 2011 until August 2014 he was a member of the math

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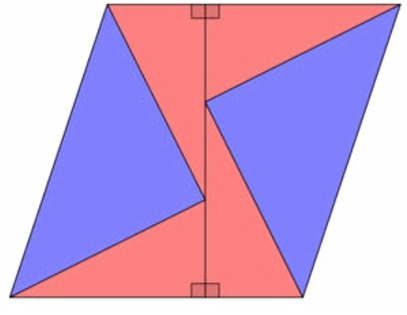
Roger and Ricela stand outside of the Department of Mathematical Sciences at the University of Montana.

Math Puzzle

By Matt Roscoe

In the summer of 2014, **Patrea Parkey**, a student in the department's Master of Arts in Teaching Middle School Mathematics program, provided the following figure in a proof of the Pythagorean Theorem. A search of the literature has yet to reveal a similar figure in any proof of the theorem. Can you construct a proof of the theorem using the figure?



iPads in the Classroom

—Continued from front

should be skeptical that educational technology will fix any problem. But perhaps the landscape is shifting. The introduction of high-speed wireless internet, smaller and more powerful devices, touch technology, and video-conferencing makes the digital world more accessible to young children.

In the fall of 2012, Paxson Elementary in Missoula launched their iPad Initiative. This program, primarily targeting students in grades 2 and 5, was made possible by the support of an anonymous donor who was "interested in integrating real-world technology into classrooms." Approximately 150 iPad 2 tablets were supplied, along with Apple TVs, charging stations, management carts, and protective cases. The students were assigned iPads for use in the classroom and allowed to take them home—much like a textbook.

This initiative supported several elements of "The 21st Century Model of Education" adopted by Missoula County Public Schools in 2011. The program would increase student engagement with projects and problems relevant to their digital world, as well as transform the traditional learning environment from "a physical place bounded by rigid schedules" to an agile learning environment that adapts to a wide range of learning styles and activities. In doing so, participating teachers would be able to reach a wider range of students and provide "equal opportunities for all students to reach their full potential."

Serendipitously, that same fall, I was searching for an internship at the elementary level to bolster my experiences teaching mathematics to young students. All my previous teacher training had been at the secondary level, so I hadn't been in an elementary classroom since I was a student in one! Many of the mathematical misconceptions I witnessed in my students at the college and high school level were rooted in concepts first introduced in the early grades. When were students developing these difficulties? Were they seemingly "simple" early mathematical concepts that persisted through the middle grades and kept the student in a consistent state of confusion? Likely, the answer is more complex, but as a life-long technology enthusiast, I couldn't help but wonder whether the right devices in the classroom at the right age might help more students master the skills they were missing.

When I first witnessed 2nd graders using iPads to write out solutions to problems, then projecting the drawing to a smartboard for the entire class to discuss, I began to wonder if the science fiction writers weren't so far off base. After all, there are numerous educational apps intended to teach mathematics, as well as many other capabilities an enthusiastic teacher might harness on these devices. However, how well did such apps work? Did students actually learn mathematics or did they just learn to play a game? Did these devices make teachers' jobs more difficult? Or did they make students enjoy math class more?

This fall, my advisor, Dr. Jim Hirstein and I began working with Peggy Manning, Sherrie Harris, Wendy Lofthouse, and Kelly Chumrau at Paxson Elementary to document their implementation of iPads in the 2nd grade classroom and attempt to answer a few of these questions. From an analysis of student work, interviews and device usage statistics, we will learn more about how iPads affect student mathematical learning and attitudes. In addition, with the benefit of two years of experience on the part of these teachers, we will be able to get a better idea of the challenges and opportunities these devices present to the educator.

Grant Swicegood is a Ph.D. student in Mathematics Education; his advisor is Professor Jim Hirstein.

Unfortunately, it is not hard to find stories about failed technology initiatives. However, we believe Paxson can provide an example of the practices that can make such an initiative a success. The answer may lie in effective professional development or quality technology support. Many teachers haven't had the training opportunities to effectively implement iPads in the classroom—after all, even an iPad Education For Dummies is available from bookstores. We hope research into this area can eventually lead to better support resources for elementary teachers trying to define how the mathematics classroom will look in the next decade.

We love to hear from our graduates!
We'd be happy to mention news from you in our next issue. You can use the Alumni Reply Form on page 7, or simply send an email to lily.rabil@mso.umt.edu.
Thanks!

Topology

—Continued from front

The idea of geometrization is important for mathematics, but the impressive generality of Perelman's theorem comes with an important shortcoming – its abstractness. Geometrization tells us that there is an intimate connection between the geometry and topology of 3-manifolds, but in practice, it is very difficult to make concrete statements. For instance, it would be nice if we could find a relationship between topological measures of complexity and geometric measures of complexity. On one hand, classical knot invariants such as crossing

In front of their work, from the left: Cody Sevier, Johnathan Bush, Andrea Johnson, Holt Bodish, and Charlie Katerba

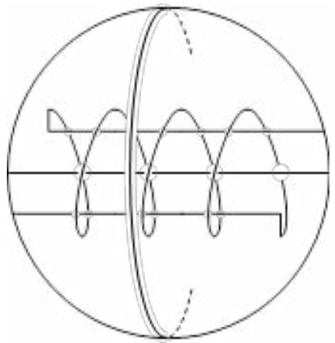
numbers and Alexander polynomials are useful measures for the topological complexity of knots and, on the other hand, one of the most useful ways to measure the geometric complexity of a knot is its volume. At first glance, large crossing numbers seem to correspond to large volume yet, after looking at many examples, we find knots which disobey this trend. One thing that we do know is that the relationship between crossing numbers and volume is complicated.

There are many specific examples of manifolds for which geometric details are known. In the years since Thurston's original work, topologists have developed effective computational techniques for understanding geometric manifolds. These techniques are utilized in the computer program "Snappea" which has, in turn, been used to build a census of data for 86,987 geometric manifolds. Because Snappea calculations are done manifold by manifold, there are very few infinite families of manifolds whose geometry is understood. This state of affairs contributes to the challenge of finding patterns in the data. Topologists want to find such patterns to make reasonable conjectures that deduce geometric properties from topological invariants.

I am supervising a small group of ambitious undergraduate and graduate students at the University of Montana who hope to make a valuable contribution to this area. Currently, Holt Bodish, Johnathan Bush, Jay Egenhoff, Andrea Johnson, Charlie Katerba, and Cody Sevier are working on this project. These students have already given numerous presentations on their work and won several awards including a Montana Space Grant Consortium Award (2011), an award for the best physical science presentation in the UM Conference on Undergraduate Research (2012), and a UM Undergraduate Research Award (2014).

Our goal is to describe explicitly the geometries of a certain infinite family of manifolds, which we call "corkscrew tangles."

Each corkscrew tangle is obtained by removing a pair of lines, tangled in a corkscrew shaped pattern, from the closed unit ball in R3. For every positive integer n, there is a corresponding corkscrew tangle, where the integer corresponds to the number of wraps in the corkscrew.



The third corkscrew tangle is obtained by drilling the 3-dimensional ball along the tangled lines.

We have singled out these particular manifolds, in part, because their geometry is complex enough to provide valuable insight into the zoo of geometric manifolds. They have the potential to contribute to the understanding of several important questions, including questions about trace fields, hidden symmetries, and the Menasco-Reid conjecture. Although complex, the geometries of these manifolds seem to be closely related to each other and the nature of this relationship gives hope for a theorem. In fact, we have already found a general method to decompose each of the corkscrew tangles into essential geometric parts. Although the geometry of each part changes from manifold to manifold, the way that these parts change follows a consistent pattern. Unraveling this pattern involves some beautiful classical mathematics including Chebyshev polynomials, Pascal's triangle, and hypergeometric functions. The more we understand patterns in these geometric pieces, the closer we get to completely understanding the geometry of the entire collection of corkscrew tangles.

Math Enthusiast – An Eclectic Mix of Interesting Reading Material

By Nikolaus Vonessen

If you have some time on your hands and like reading about math, you might enjoy looking at the December issue of The Mathematics Enthusiast. This journal, formerly known as The Montana Mathematics Enthusiast, is edited by Professor Bharath Sriraman, and is freely accessible at http://www.math.umt.edu/TMME/. The authors of the December 2014 issue include, among others, both students and faculty from our department. I particularly enjoyed the article by Professor Karel Stroethoff about a remarkable approximation of the sine function found by the Indian mathematician Bhaskara in the 7th century. A paper by Tien Chih, a former Ph.D. student who is now an assistant professor at Newberry College in South Carolina, presents examples to show that the famous Cantor-Schroeder-Bernstein theorem does not extend to many settings involving more structure than ordinary sets. There are also three articles by undergraduate students, Jay Egenhoff, Daniel R. Lande and Phoebe Webb, which originated as exceptional term papers for Bharath Sriraman's History of Mathematics class last spring. But there is much more, including a book review by Assistant Professor Cory Palmer of "The Tower of Hanoi – Myths and Maths". Have a look yourself!

Graduate Fellows—Continued from pg 3

faculty at Blackfeet Community College, where he taught all the courses ranging from M 060 to STAT 216. He was also the PI on a pre-engineering grant from the Nuclear Regulatory Commission. This grant established a 2-year pre-engineering program preparing students to transfer to a 4-year program. Three BCC students have finished the program and transferred to MSU. Another 5 are enrolled and working towards this goal.

Roger is interested in pure mathematics and hopes to study either algebra or analysis. He plans to pursue a Ph.D. and to become a professor. He would particularly like to be able to help native students make the transition from tribal colleges to larger universities.

Roger is also the recipient of a Sloan Fellowship. One of his tasks is to reestablish an AISES chapter (American Indian Science and Engineering Society) on our campus. This society has as a goal to bring more native students into STEM fields. They hope to accomplish this partially by also establishing high school chapters of AISES.

We are delighted to have both Ricela and Roger in our program and wish them the best of luck!!

Brian Steele wins IBM Award–

Continued from front

award, which includes a $10,000 prize, recognizes Brian's efforts in developing coursework in big data.

Big data analytics is an in-demand skill, with application in many areas including business, computer science, government and law. In addition to courses in the nuts and bolts of big data analytics, Brian has developed a big data projects class which matches teams of undergraduate students with local (both on and off-campus) and national companies and organizations looking for help. The course ran for the first time last spring and was well-received by the clients. It will run again this spring semester with a new set of students and projects.

Brian Steele stands outside of the Department of Mathematical Sciences.

There are two things that distinguish UM's Big Data Certificate program from programs at other universities. One is that Brian has developed completely new courses to serve this program rather than simply adapting existing courses to the effort. The second is that this program is oriented towards undergraduate students.

The effort to develop big data courses has been challenging and time-consuming for Brian. He has had to become competent at programming in C, Python, Infosphere Streams, and Java, and proficient at working in the Linux environment and on the Eclipse platform. He has also learned about a variety of big data applications including sentiment analysis, network traffic and packet analysis, and teleconferencing systems. IBM's award is a well-deserved recognition of Brian's efforts. Congratulations, Brian!

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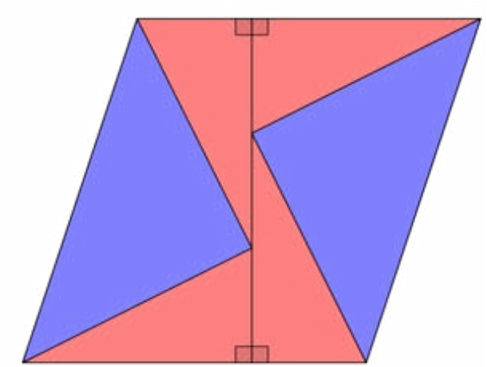
Math Puzzle Solution



In the congruent red triangles, label side lengths ***a***, ***b*** and ***c*** in order of magnitude. Since the two non-right angles of a right triangle are complementary the blue triangles are also right. So, the area of the figure can be calculated by summing the areas of the 6 triangles:

$$4\,(\tfrac{1}{2}\,ab) + 2\,(\tfrac{1}{2}\,cc) = 2ab + c^2$$

Now, the figure can be shown to be a parallelogram. The area of a parallelogram is calculated by the product of the length of the base times the altitude:

$$(a+b)(a+b) = a^2 + 2ab + b^2$$

Since the two areas must be equal we have

$$a^2 + b^2 = c^2$$

and the theorem has been proved.

UNIVERSITY OF MONTANA
Department of Mathematical Sciences (MMAI01)
Mathematics Building
Missoula, MT 59812-0864
Phone: 406-243-5311
Website: hs.umt.edu/math

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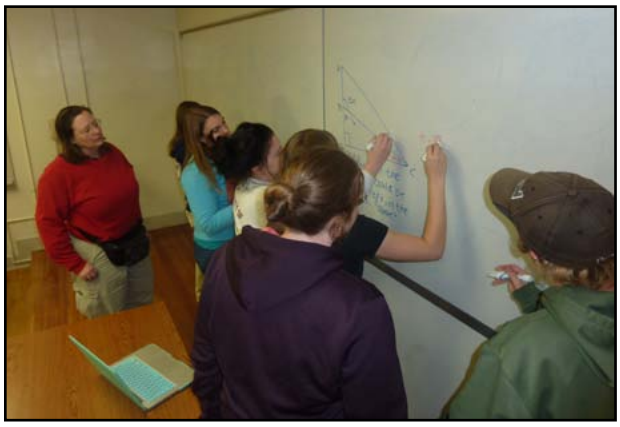
Math Club Corner

Dear Alumni and Friends,

I am excited to announce that the University of Montana Mathematics Club (Math Club) has been revived! Weekly meetings are held on Tuesdays in Math 103 from 3:10 – 4 P.M. and are open to anyone who shows an interest in Mathematics. I encourage all of you to attend. Our meetings are a place for students to enhance problem solving skills and to practice presentations.

Last semester was Math Club's first step to success with a fundraiser on Pi Day. Math Club partnered with the University's Economics Club and made a $464 profit. Over the summer, our President and Vice President, Johnathan Bush and Jessica Hurd, were sent to Pi Mu Epsilon's Centennial Event, MAA Math Fest 2014 in Portland, Oregon where Jonathan gave a presentation titled "Leibniz's Infinitesimals" relating to his undergraduate research. Johnathan and Jessica also attended presentations given by other undergraduates as part of Pi Mu Epsilon, participated in student activities, and visited exciting locations in Portland.

Our goals for this academic year are to host a fundraising event, recruit more members, contribute to the community, and be able to send a delegate or two to the MAA Centennial Event during the summer of 2015 in Washington D.C. One of the fundraisers will be the traditional Pi Day fundraiser held near March 14th.



Math Club members are busy working on problems during a meeting

I again express my excitement in the revival of Math Club and we hope to make it a continuously successful student group!

Jennifer Nelson, Math Club Secretary

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