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The BIG Notebook

A Newsletter of the MAA Special Interest Group for Mathematics in Business, Industry & Government

Love of Music Leads to a Mathematics Career
by Carla Martin, James Madison University

Igor Stravinsky, 20th century Russian composer, said, "Musical form is close to mathematics -- not perhaps to mathematics itself, but certainly to something like mathematical thinking and relationship." You have no doubt heard of the interplay between math and music. I use it to explain my later interest in mathematics after spending my entire childhood and adolescence dreaming of a life as a violinist.

In college I was concertmaster of the university symphony, but I was starting to be inspired by another subject … mathematics. After initial trepidation towards the subject I realized that I enjoyed mathematics problems as much as playing the violin. Once I realized there were measurable connections between math and music I was hooked. I immediately changed my major to math and spent my last two years working on a project that combined music and mathematics that still seems to attract attention today.

My interest in mathematics has always been about its applications and connections with other fields. Shortly before graduation, I had trouble narrowing down my career goals. While I desperately wanted to attend graduate school, the timing did not seem ideal for me. Instead, I accepted a consulting job at PricewaterhouseCoopers (now a part of IBM Global Business Serv-

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Professor Carla Martin,at the top of Lost Arrow Spire, in Yosemite National Park.

Inside:

ices) in the Washington DC area. This was an ideal job at the time, as I loved working math problems and I loved working with people. Consulting incorporated both of these aspects and also allowed me to participate in many different projects, each with new challenges.

I worked on numerous projects. My favorite project was for the National Highway Traffic Safety Administration (NHTSA). NHTSA noticed an increase in single-car accidents since anti-lock brakes (ABS) became standard on most cars. To understand this correlation, we performed a study on driver experiences with ABS and determined that the increase of single-car accidents was attributed to driver error when the ABS engaged (panic, overconfidence, etc.). The results were used by NHTSA to plan activities that addressed the public's knowledge of ABS in order to improve public safety.

I also mined large amounts of data. Supermarket shopper cards are one such example where consumer purchasing histories are used for targeted coupons. My particular project involved mining credit card transactions in order to target coupons on credit card statements. This is perhaps the most mathematical of the projects I describe here; techniques used involved nearest-neighbor models as well as neural network models.

I continued as a violinist by joining two symphony orchestras in the area. Always up for a new challenge, I dabbled in some mountaineering adventures that included a summit attempt of Mt. Shasta, a 14,000 ft glaciated volcano in northern California. After several other adventures, I had a new sport as well: rock climbing. Just as my extracurricular interests were shifting, so were my professional interests. The mathematics itself, rather than simply the application, was now becoming my focus. Though on a very successful career path, after four years I left consulting

Editor's Note

BIG SIGMAA's small size and limited funds mean that it cannot always shoot for the stars. Still, there are signs that BIG SIGMAA is making a progressively greater impact and gaining in recognition. One of our newer programs is the Invited Speaker program at the Joint Mathematics Meetings. Starting with the terrific inaugural talk by Algorithmic Origamist Robert Lang, the program has maintained a string of top talent, namely Dan Kalman of American University, freelance mathematical writer Barry Cipra, and this year's speaker, Tony DeRose of Pixar.

The invited talks are not the only sign of success, however. The Contributed Paper Sessions have begun attracting bigger audiences, even filling large lecture rooms. Two of the speakers in this year's well-attended session agreed to contribute to this issue of the newsletter, to give an idea of their work. Petronela Radu at the University of Nebraska at Lincoln describes her "Math in the City" program, which involves students in solving problems for cities and municipalities. Carl Moravitz of IBM describes the possibilities for mathematicians to make a difference in making government run more efficiently.

BIG SIGMAA is also blessed with a new Vice Chair for Operations, Carla Martin. Her profile article in this issue gives an idea of the energy and talent she brings to our special interest group. And in a first for this newsletter, we have articles by a father (Carl Moravitz) and his daughter (Carla Martin).

This issue also includes an example of JoAnne Growney's mathematical poetry. You can enjoy more examples of mathematics combined with poetry, and more of her art, at her poetry blog. http://poetrywithmathematics.blogspot.com.

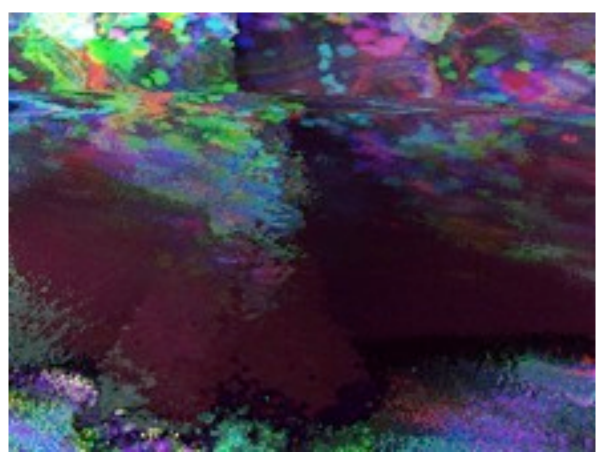
for a Ph.D. program in Applied Mathematics at Cornell University.

While in graduate school, I continued playing violin, and eventually taught rock climbing in addition to teaching calculus! I enjoyed cross-referencing teaching examples in both climbing and math classes. The music-and-math relationship was endemic throughout both departments. The symphony orchestra at Cornell was made up of over 50 percent science/math/engineering majors. The Cornell Math Department puts on a spring concert each year that showcases musical talent from its faculty, staff, and students. The standard of musical talent at these concerts was just as high as other high quality amateur chamber music concerts in the area. It was an exciting place to be.

At first, the transition from consulting to graduate school was difficult. My peers were not transitioning from the working world and many of my professors had never worked outside of academia. I used a different mode of thinking and was unable to figure out how to make my professional experience work to my advantage Eventually I realized that my work experience provided me with better focus and career goals. I wanted to be in academia and more importantly I wanted to be in a position that could inspire others to pursue mathematics by demonstrating its ubiquity across many application areas. My research area is numerical linear algebra and in particular extending linear algebra factorizations to tensors. Somehow I had come full circle. I was now working on problems in many application areas such as image processing, data mining, and chemistry since multidimensional data techniques are crucial in these areas.

My interest in seeking the interplay between various fields has defined my professional research since graduate school. I have continued work in tensor decompositions with applications in imaging, geology, computer science, and communications. As a faculty member at James Madison University, I have worked to inspire students to pursue mathematics-related careers by introducing them to the plethora of applications in various areas. I have made it a priority to introduce research-like thinking into the classroom, which helps students to question results and think critically. My approach to teaching always emphasizes a real-life connection. I just co-authored a book with Anthony Tongen called "Keeping it R.E.A.L.: Research Experiences for All Learners" published by the MAA that includes a description of real life in-class projects designed to develop critical thinking skills in the classroom.

I still play the violin and rock climb. Along the lines of seeking out new challenges I've now completed several triathlons. Though lately my biggest challenge has been raising a 7, 4, and one-year old to enjoy the world around them.



Ocean of Color, by Collin Carbno

A Mathematician's Nightmare, by JoAnne Growney, from her mathematical poetry blog

http://poetrywithmathematics.blogspot.com

(27 March 2011 entry, "The Nightmare of an Unsolved Problem")

Suppose a general store,
items with unknown values
and arbitrary prices,
rounded for east to
whole-number amounts.

Each day Madame X,
keeper of the emporium,
raises or lowers each price,
exceptional bargains
and anti-bargains.

Even-numbers prices
divide by two,
while odd ones climb
by half themselves
then half a dollar more
to keep the numbers whole.

Today I pause before
a handsome beveled mirror
priced at twenty-seven dollars.
Shall I buy or wait
for fifty-nine days
until the price is lower?

Background on the poem "A Mathematician's Nightmare"

by JoAnne Growney (from the 27 March 2011 entry of her blog - see adjoining column)

Back in the 1980s when I first met the Collatz conjecture in a number theory textbook it was stated this way:

Start with any whole number n :
If n is even, reduce it by half, obtaining n/2.
If n is odd, increase it by half and round up to the nearest whole number, obtaining $3n/2 + 1/2 = (3n+1)/2$.

Collatz' conjecture asserts that, no matter the starting number, iteration of this increase-decrease process will each time reach the number 1.

For example, we have

$13 \rightarrow 20 \rightarrow 10 \rightarrow 5 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1$ (7 steps)

$23 \rightarrow 35 \rightarrow 53 \rightarrow 80 \rightarrow 40 \rightarrow 20 \rightarrow 10 \rightarrow 5 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1$ (11 steps)

On the other hand, when we use 27 as a starting number, it requires 70 steps before the sequence reaches 1; after climbing as high as 4616, it drops below 27 for the first time -- to 23 -- on the 59th step.

The Collatz conjecture (first proposed by Lothar Collatz in 1937) remains unsolved. During the last 20 years, the conjecture has been known by several names and is often called "the 3n + 1 conjecture." Because I have spent many many sleepless hours working on the Collatz conjecture, when I describe it in a poem, my title is "A Mathematician's Nightmare." (Also in the background of my poem is myself as unskilled bargain hunter -- getting a best buy rarely and always by accident. In the poetic case, at least, my mathematical knowledge helps me to know the right amount of time to wait for a good price.)

Feather Web, by Collin Carbno

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Math in the City
An Example of Hands-On Learning in Mathematics

by Petronela Radu, University of Nebraska at Lincoln

I hear and I forget
I see and I remember
I do and I understand.
- Chinese Proverb

It has been a long-held belief of educators that students learn not so much by watching their teachers, but by doing what their teachers are doing. In math classrooms we usually follow this principle by asking our students to do exercises that reinforce the material (compute the integrals, solve the equations etc.), but in our choices for practice problems we often lose the connection with what that material was about and provide little description of how the material fits with our students' lives, especially after graduation. Our students, however, are the engineers, the traffic controllers, the doctors of tomorrow. As a parent of three children, the responsibility of providing a good quantitative education to the next generation lies a little more heavily on my shoulders.

My undergraduate training in mathematics in Romania was exceptional, but unfortunately it lacked this important facet: the case for the applicability of the material was not always made. It was during my graduate studies at Carnegie Mellon University that I learned from a great group of applied mathematicians (including my thesis advisor, Luc Tartar) the importance of knowing where the problem or model comes from. It was then that I was taught, and slowly understood, that knowing the physical motivation of the problem is important not only to the engineers, but to the mathematicians as well, because the physical origin of a problem very often leads you to a nice mathematical solution, to that simple beautiful solution that in Erdos' words is "from the book of God". After my graduation from CMU, when I was teaching differential equations at the University of Nebraska-Lincoln, I was taken aback to see that many bright students had such a difficult time solving word (a.k.a. "applied") problems; that going from "Solve this equation" to "In a water tank there are 100 gallons of water ..." meant crossing a bridge to an intimidating world that could be much larger and less structured than the beautiful realm of mathematics. This is when and how the idea for designing an interdisciplinary type of course in mathematics came to my mind.

Math in the City Workshop participants, Dec 2010: (Standing, left to right: A. Hariharan (UNL), S. Billups (UC-Denver), J. Grout (Drake U.), A. Kolesnikov (Towson U.), D. Auckly (Assoc. Director, MSRI), K. Simic (Pacific Lutheran), G. Ledder (UNL), B. Swanson (Neb. Wesleyan), S. Pankavich (USNA, UT-Austin); sitting, left to right: M. Uhrig (UNL), P. Radu (UNL), S. Hartke (UNL).

From the very beginning I believed that any sort of interdisciplinary course should be in collaboration with businesses or research centers, that for this course we should leave the academia setting which students often associate with sanitized data, "thought" experiments, and textbook-type applications. I wanted the real "dirt" of the math applied outside the classroom, something that even I had never experienced before.

Anne Bradford, Brittany Bunker, Austin Barnes (standing) and Zhi Qu using SAGE to solve a recycling company's routing problem.

In the Spring of 2006 I taught the first version of this course that I called Math in the City (you all know what show I was watching back then). Looking back, this name has been inspirational because it truly reflects what we are doing in the classroom: groups of 3 to 4 students work during the semester on a project that arises as a mathematical model in the work of a business or research center in our city of Lincoln, Nebraska. We have been fortunate from the very beginning to work with exceptional collaborators, so that the first two projects (a statistical analysis of risk factors for heart disease in collaboration with the University of Nebraska Medical Center, and a model for water levels in Nebraska's largest lake, Lake McConaughy in collaboration with the Nebraska Department of Natural Resources) ended up with some surprising and quite interesting results. Thus, even though during that semester I went outside my comfort zone in teaching quite often, I got hooked on the course and I started seeing its transformative potential in the students' education.

The course has been offered four times, and for these offerings we have had diverse topics for the projects. Students conducted a statistical investigation to decide whether the nationwide "bubble" in the real estate market was also experienced in Lincoln (in collaboration with the Lincoln County Assessor); modeled traffic in our city's downtown and highways (with The Schemmer Associates); analyzed investments versus costs in sustainable "green" design in two LEED-certified buildings (with the Architectural Partnership); solved routing problems for local recycling companies (with the City of Lincoln Recycling program and two local recycling companies). LEED is an acronym for ``Leadership in Energy and Environmental Design.'' A key feature of all these projects has been the relevance of the topics to the students. We tried to choose front page topics that would attract students and keep them motivated throughout the semester.

It was during a seven year drought that we analyzed the water levels in Lake McConaughy, when this topic was discussed on the radio, local TV programs, and in the newspapers. The importance and need for sustainable design was becoming clear locally and nationally when our students learned about its advantages and how to model its financial effectiveness and green benefits. Last Fall, at a time of high gas prices, students had to analyze truck routes, to find ways to decrease fuel costs, which are the largest expense for the local recycling companies.

Through each of these projects we have benefited from the expertise and help of many collaborators, who often went out of their way to help us obtain more data and information for the project. We keep in touch with the collaborators throughout the semester and, for each project, the students visit the collaborator's workplace to experience first-hand the non-academic work environment. Last fall, for example, students went to see what some people call the "eighth wonder" of the city – the city's landfill; there, at the highest point in town we got to appreciate the engineers' intricate work in building this "monument." The students also visited one of the recycling companies in town, so they experienced fully the importance of "reduce, reuse, recycle."

Dan Wiechert (left) and Dennis Rogers (back to camera) present at the Nebraska Research and Innovation Conference, October 2010.

Another important aspect of Math in the City that makes it different from a traditional math course is that it gives students an incredible opportunity to exercise and improve their communication skills. Students learn how to efficiently and precisely report on the work they have done; they have to learn to use their communication skills in the interaction with their peers in the group. During the final weeks of the course the students have a most rewarding experience by presenting their results after completing the work on the project. The entire group writes and also each student participates in the group's slide presentation about their work and findings. For many students this is the first time that they have to present mathematical content to an audience formed by their peers, other students, faculty members in the Math Department, and business partners. The experience they take from giving their talks will serve them well in the future especially during job interviews and other career presentations. The students have also attracted interest in their work at conferences and research events by giving poster presentations. The boost in self-confidence that these experiences give the students is a valuable gift for the start of a successful career later on.

In 2009, as the course was gaining more momentum it was clear that the program would need to be further developed to reach its full potential; there was also a desire to disseminate the course to other institutions. In this endeavor, I partnered with my colleague, Stephen Hartke, and applied for NSF funding, which we were elated to receive; this marked a new phase for the course. In the Fall of 2010, Stephen and I taught the course together to see which aspects could be improved or further developed. We have also been preparing materials for the course to ensure its long term sustainability. For the course dissemination we are organizing yearly workshops where instructors interested in offering the course at their institutions learn about the nuts and bolts of teaching this class.

We hope that hands-on learning and research experiences, such as Math in the City, will be part of the undergraduate curriculum at many colleges and universities across the US. Such programs show the students the need for mathematics while the students are still in our classrooms, can ask questions and learn. These are great opportunities for students and instructor to be immersed in real life while doing mathematics, leaving them all with a rewarding and unforgettable experience.

Strategic Use of Analytics in Government
by Carl Moravitz

Our nation is on an unsustainable fiscal path. Spending is rising and revenues are falling short, requiring the government to borrow huge sums each year to make up the difference. We face staggering deficits. In 2010, federal spending was nearly 24 percent of Gross Domestic Product (GDP), the value of all goods and services produced in the economy. Only during World War II was federal spending a larger part of the economy. Tax revenues stood at 15 percent of GDP this year, the lowest level since 1950. The gap between spending and revenue – the budget deficit – was just under nine percent of GDP.

Since the last time the Federal budget was balanced in 2001, the federal debt has increased dramatically, rising from 33 percent of GDP to 62 percent of GDP in 2010. The escalation has been driven, in large part, by two wars, various fiscal decisions over the decade, along with a deep economic downturn.

The recent growth in government budget deficits severely constrains the policy choices and operations of all government organizations. The current budget levels of the Federal Budget exceed \$3.8 trillion, a deficit of over \$1.5 trillion, and a national debt of over \$14 trillion. What can be done to create more financial flexibility for federal organizations in their service to taxpayers, while, at the same time, reducing the pressure on the continued rising of federal deficits? There are significant, practical, and achievable opportunities for cost reductions and value creation, but their success and strengths rest in improving analytical capacity.

There are many problems that have contributed to budget deficits in government today. These include revenue shortfalls, rising entitlement spending, unplanned expenses, higher than required expenditures for mission, and higher than required expenditures for general and administrative costs. Alongside these challenges, the Government also faces longstanding barriers to achieving sustainable cost savings. Historically, the U.S. government has demonstrated a limited ability to systematically improve efficiency and business performance and ensure that the nation gets its money's worth. This inability comes from, among other things, a lack of analytical capacity, as well as limited leadership possessing practical business management experience.

How are successful government executives meeting such challenges? One technique is through the strategic use of analytics. "Analytics" is the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions. When used together, analytics and fact-based decision-making can make a powerful contribution to the success of a wide range of government missions. However, these approaches are not being used as broadly as they are in the private sector.

At our recent Conference in New Orleans, I spoke on the potential use of strategic analytics in government, specifically its use across four key governmental issue areas: (1) health care; (2) military logistics; (3) tax collection; and (4) intelligence. While analytics is often depicted as a technological innovation, in fact, analytic approaches require managerial innovation to be successful.

Technological advances have created new opportunities for the use of analytics. Breakthroughs in data-capturing technologies, data standards, data storage, and modeling and optimization sciences have created opportunities for large-scale analytics programs. I noted at the Conference that successful analytics programs exhibit the following characteristics:

Accessible, high-quality data

An enterprise orientation

Analytical leadership

A long term strategic target

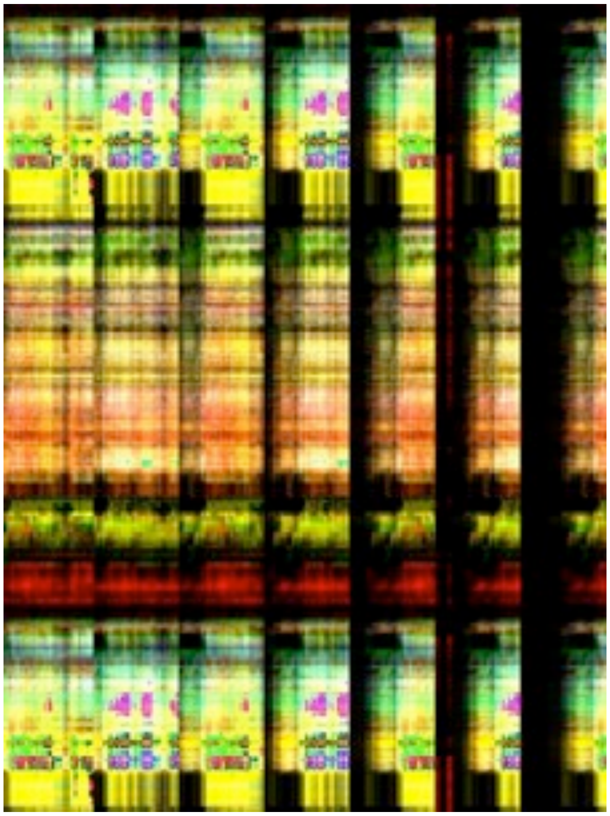
A cadre of analysts

Private sector organizations have successfully used analytics to maximize competitive advantage and developed sustained competitive advantages from the use of data-based analytics. Success stems from their ability to utilize investments in enterprise software, point-of-sale systems, and electronic commerce. Many organizations have used analytics to change the way they compete.

Government has had real, but limited, success in the implementation of data analytics. Some areas of government are exploiting the use of analytic methods to meet their strategic goals. At the New Orleans Conference, I shared some examples of Government successes:

Health Care: Using Analytics to Prevent Fraud
Supply Chain: Using Analytics to Plan Capacity
Tax Collection: Using Analytics to Forecast Revenue
Intelligence: Using Analytics to Model Operational Forecasts

Government needs to grow its analytical capacity. While there are many examples of the successful use of analytics in government, government today still lacks the needed elements of leadership, an enterprise-wide orientation, and long-term strategic targeting, all of which are important factors in successful analytic programs.



Curtains of Color, by Collin Carbno

Quotation Corner

The discovery in 1846 of the planet Neptune was a dramatic and spectacular achievement of mathematical astronomy. The very existence of this new member of the solar system, and its exact location, were demonstrated with pencil and paper; there was left to observers only the routine task of pointing their telescopes at the spot the mathematicians had marked.

-- James R. Newman, in ``The World of Mathematics (Simon and Schuster, NY, 1956).

Contributed Papers Presented at the BIG SIGMAA Session at the JMM in New Orleans, January 2011

Petronela Radu, University of Nebraska at Lincoln, ``Math in the City: A Hands-On Learning Experience in Mathematical Modeling.''

James Fife, Educational Testing Service, ``Improving the Performance of Open-Ended Mathematics Questions.''

William Fox, Michael Minutas and John Binstock, Naval Postgraduate School, ``Building Models and a Methodology for Using Techologies to Detect Suicide Bombers.''

Candace Rockell Gerstner and John Tweed, Old Dominion University, ``Updates on a Green's Function Code for Radiation Transport.''

Mike O'Leary, Towson University, ``Patterns in Criminal Offender Distance Decay.''

Vincent Dimiceli, Engineering, Oral Roberts University, and Steven Piltz, ``Estimation of Black Globe Temperature for Calculation of the WBGT Index.''

Carl Moravitz, IBM, ``The Strategic Use of Analytics in Government is a Powerful Resource in Achieving Federal Missions.''

Timothy Anderson and Allen Butler, Daniel H. Wagner Associates, ``Bayesian Inference for Rapid Social Networking Analysis.''

Sonja Sandberg, Framingham State College, and Steven Anderson, ``The U.S. Blood Supply, Bioterrorism and Mathematics.''