The BIG SIGMAA News

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Business, Industry, and Government Special Interest Group of the Mathematical Association of America

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Note to Readers:

If you would like to contribute an article, a poem, a puzzle, or anything else to future issues of the newsletter, please let me know.

Jim Fife
Vice Chair for Services
jfife@ets.org

At JMM 2018—Contributed Paper Session on BIG Mathematics

The contributed paper session on BIG mathematics at the 2018 Joint Mathematics Meetings was held on Friday morning, January 12. Ten speakers from universities, industry, and the military spoke about their experiences with mathematics in business, industry, and government.

William Fox from the Naval Postgraduate School, the BIG SIGMAA's outgoing vice chair for programs and one of the organizers of the session, started things off at the early hour of 7:40 am (though perhaps not so early for East Coasters still somewhere in the Midwest, time-wise). Dr. Fox discussed various weighting schemes that can be used when assessing the importance of different factors in ranking objectives. He concluded that using any weighting scheme is better than not using a weighting scheme at all.

The BIG SIGMAA's incoming vice chair for programs, Colonel Robert Burks, also of the Naval Postgraduate School, was next. His talk was entitled *Modeling the Human Terrain*. Modern military research tries to develop an understanding of complex interactions among all the elements of society, including people, social and religious groups, governments, criminal elements, and physical infrastructures, and how these interactions will affect Special Operations Forces in the conduct of today's military operations that are "more fervent than normal ... diplomacy, yet short of conventional war." This research merges several lines of study, including epidemiology diffusion research, social network analysis, and agent-based modeling. The work combines elements of voting theory, risk theory, utility theory, and game theory.

The next speaker was Paul Fishback from Grand Valley State University, whose talk had the engaging title *A Mathematician, Engineer, and Brain Surgeon Walk into a Bar: Collaborating with Biomedical Engineers and Neuroscientists in the Study of Epilepsy*. Evaluation of an epilepsy patient's candidacy for surgical intervention requires determining the portion of the patient's brain from which seizures are generated. Biomarkers of this region can be identified through analysis of EEG records. Dr. Fishback showed how mathematical models involving integral transforms can be used, together with machine-learning techniques, to identify these biomarkers.

James H. Fife from Educational Testing Service discussed a research project involving student use of equa-

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The Puzzle Corner

An urn contains a number of colored balls, with the same number of balls in each color. If 20 balls of a new color are added to the urn, the probability of drawing (without replacement) two balls of the same color is not changed. How many balls are in the urn (before the new balls are added)? (*Solution on page 4*.)

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tion editors versus handwriting responses when responding to on-line test questions. Dr. Fife reported that it generally takes students longer to respond on a computer with an equation editor than to provide a handwritten response, and the more complicated the expression, the greater the time difference. There is a small order effect, with the difference in response times being slightly smaller if the student enters the response on the computer first. The most difficult aspect of using an equation editor seemed to be the proper navigation through templates. And finally, the handwritten responses were written on an iPad and handwriting recognition software was used to convert the handwritten responses into MathML; the conversion generally preserved the general structure of the equation but frequently misidentified individual characters.

Aihua Li talked about a PIC Math class she taught at Montclair College. PIC Math (*Preparation for Industrial Careers in Mathematics*) is a joint program of the MAA and SIAM that prepares mathematics students for industrial careers by engaging them, as part of their undergraduate education, in research problems that come directly from industry. (For more information about PIC Math, see the article by Suzanne Weekes in the Spring 2016 BIG SIGMAA newsletter.) Dr. Li's PIC Math class had 24 students, mostly juniors and seniors majoring in mathematics. They had all taken Calculus I and II and Linear Algebra. The students were divided into four groups, with each group working on a different project. During the course of the semester each group gave three oral presentations and at the end of the course each group submitted a written report. The work resulted in five student presentations at research conferences. Dr. Li reported that, by working on real industrial problems, the students in the class improved their critical thinking, their problem-solving skills, and their communications skills, better preparing them for industrial careers.

Tracy Bibelnieks, from the University of Minnesota, Duluth, described her experiences tutoring student teams in data analytics competitions. By participating in these competitions, student learn what real-world data look like, they understand the significance of translating a BIG problem into a data analytics problem and then translating the data insight back into the language of the original problem, and they see the challenge and importance of being able to navigate ambiguity. Students learn that real data are messy and may require careful analysis before yielding the answer to the question that has been posed. Dr. Bibelnieks concluded her talk by giving four examples of BIG problems that can be approached through data analysis.

Captain Patrick Kuiper from the United States Military Academy talked about using free-response survey questions instead of Likert-based multiple-choice questions for student course surveys. Responses can be analyzed with standard natural language processing (NLP) techniques, such as word frequency and sentient analysis. Responses to free-response questions were more useful to instructors than Likert responses and the researchers feel that the NLP analysis gives reliable results.

Uma Ravat from the University of Illinois talked about her experience teaching a PIC Math course. Of particular interest in her talk were some pointers for professors contemplating a PIC Math course of their own. For example, one challenge for prospective PIC Math teachers is to find suitable industrial projects. Dr. Ravat had some useful advice here. She suggested to start looking for projects early, to talk with faculty in other departments and with staff in the university's

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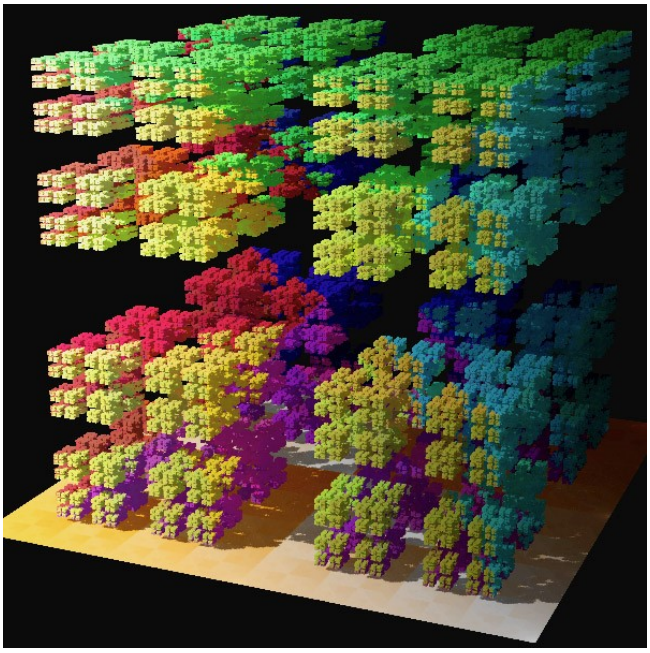
Joint Mathematics Meetings 2019 in Baltimore

The 2019 Joint Mathematics Meetings will be held in Baltimore from January 16 through January 19. The preliminary program is available on the Joint Meetings website (`jointmathematicsmeetings.org`). Highlights include the Gibbs lecture by Alan Perelson from the Los Alamos National Laboratory and the Porter lecture by Cathy O'Neil from ORCAA, author of the book *Weapons of Math Destruction*. The MAA will be hosting a number of contributed paper sessions; the JMM website includes descriptions of each (click **Program**, then **MAA Call for Papers)**. The contributed paper session on BIG mathematics, sponsored by the BIG SIGMAA, will be held on Friday morning. The deadline for submitting an abstract to any of these sessions is September 25. To submit an abstract, go to the JMM website, click **Program**, then click Submit an **Abstract.**

Georg Cantor

2018 is the one hundredth anniversary of the death of Georg Cantor. He was born on March 3, 1845 in St. Petersburg, Russia, and died on January 6, 1918 in Halle, Germany. He is probably best known for showing that the rational numbers are countable but the real numbers are not; that is, there is a one-to-one correspondence between the natural numbers and the rational numbers but not between the natural numbers and the real numbers. This implies that there are different levels of infinity—in fact, that there are infinitely-many levels of infinity.



To mark the anniversary of his death, there are three quotations from Cantor:

> The fear of infinity is a form of myopia that destroys the possibility of seeing the actual infinite, even though it in its highest form has created and sustains us, and in its secondary transfinite forms occurs all around us and even inhabits our minds.
>
> In mathematics the art of proposing a question must be held of higher value than solving it.
>
> The essence of mathematics lies in its freedom.

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career center, and to contact local businesses through the Chamber of Commerce and organizations like the Rotary Club. Also, of course, use the usual networking sources like LinkedIn, conferences, job fairs, and so on. A particularly good bit of advice is to not say "I am looking for mathematics problems for students to work on." Rather, ask contacts in business what their problems are, and look for problems that are amenable to mathematical or data analysis.

Joe Eichholz from Rose-Hulman Institute of Technology also talked about a PIC Math course he led with Christina Selby. In his talk, he mentioned some of the special problems with PIC Math courses when most of the students are primarily engineering majors, with maybe mathematics as a secondary major. He also discussed some issues to consider when selecting industrial sponsors; for example, it's important that the sponsors are willing to be wait-listed for a year if not enough students enroll in the PIC Math course. He pointed out that the quality of the interaction with the sponsor has an impact on the motivation of the students and the quality of their work. The second time he taught the course he established regular assignments, or milestones, including reading assignments and oral or written reports. These milestones resulted in the students producing better reports and communicating better with the sponsors.

Finally, Shirley Yap of California State University, East Bay, also talked about a PIC Math project. For this project, her students used machine learning techniques—specifically, neural networks—to find synonyms for a given list of words through an analysis of thousands of documents.

Business, Industry, and Government Special Interest Group of the Mathematical Association of America

BIG SIGMAA serves as a unifying link between business, industry, and government mathematicians, academic mathematicians, and mathematics students. The SIGMAA provides resources and a forum for MAA members who share an interest in mathematics used in business, industry, and government, aids in professional development, helps build partnerships between industry and academics, and increases awareness of opportunities for mathematicians in business, industry, and government.

Puzzle Corner Solution

Suppose there are originally n balls in the urn in each of c different colors, where $n > 1$ and $c > 1$. Then there is a total of cn balls in the urn and so the number of ways of drawing two balls is $cn(cn - 1)$. The number of ways of drawing two balls of a particular color is $n(n - 1)$, so the number of ways of drawing two balls of the same color is $cn(n - 1)$. Thus the probability of drawing two balls of the same color is $cn(n - 1)/cn(cn - 1) = (n - 1)/(cn - 1)$.

Now suppose k balls of a new color are added to the urn. There are now $cn + k$ balls in the urn, and so the number of ways of drawing two balls is $(cn + k)(cn + k - 1)$ and the number of ways of drawing two balls of the same color is $cn(n - 1) + k(k - 1)$. Therefore the probability of drawing two balls of the same color is now $[cn(n - 1)+k(k - 1)]/[(cn + k)(cn + k - 1)]$.

Since these two probabilities are equal, we have

$$\frac{n-1}{cn-1}=\frac{cn(n-1)+k(k-1)}{(cn+k)(cn+k-1)}$$

or

$$(n-1)(cn+k)(cn+k-1)=(cn-1)\left[cn(n-1)+k(k-1)\right]$$

Simplifying, dividing by nk, and regrouping, we have $c(k + 1 - 2n) = k - 1$. When $k = 20$ this yields $c(21 - 2n) = 19$. Since c is an integer and $c > 1$, the only solution is $c = 19$ and $n = 10$. Thus there are $cn = 19 \times 10 = 190$ balls in the urn originally.