Publisher's Editorial

The Doug Faires Awards for 2017

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Introduction

COMAP is proud to announce the winners of the second annual Doug Faires Award. The purpose of the award is to encourage and recognize efforts to start modeling teams at both the high school and college levels.

COMAP wishes to encourage current faculty advisors to reach out, recruit, and mentor new faculty advisors at either the college or high school level, particularly at nearby schools. The goal is to form local groups with a common interest in mathematical modeling.

We dedicate this award to Doug Faires, who provided us with the perfect example of the goals we wish to attain. First, a snapshot of Doug Faires:

About Doug Faires

Doug served first as a faculty advisor for the undergraduate Mathematical Contest in Modeling (MCM)™. He also gave talks to local high schools, inviting them to form modeling teams to compete in the High School Mathematical Contest in Modeling (HiMCM)™. He recruited and mentored high school faculty advisors and invited them and their teams to Youngstown State University, where the teams met one another and the experienced members of the college teams mentored the high school students. Long-term bonds were formed, and each year college and high school teams were encouraged to participate in the modeling contests, including the Interdisciplinary Contest in Modeling (ICM)™. Additionally, teams were given feedback by Doug and others after the contest was over. Later, Doug served as a Final Judge for the MCM, where he again was a true leader.

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Our Goal for the Award

Our goal is to emulate Doug's success at the local level.

The Doug Faires Award will be given for individuals who achieve great results in a particular year or cumulative excellent results over a period of time.

This Year's Awardees

This year's **Lifetime Achievement Award goes to Daniel J. Teague of the North Carolina School of Science and Mathematics (NCSSM)**. In 2017, he had two Outstanding teams in the ICM, in the Airport Security and Migration to Mars problems; his past achievements are detailed below.

The award for a **Single Year's Achievement goes to Prof. Xiaofeng Gao of Shanghai Jiao Tong University** for being the advisor to 52 teams in the 2017 MCM/ICM, 6 of which were Outstanding.

Both of this year's Doug Faires Award recipients have extremely interesting stories to tell about their experiences in mathematical modeling, as students and as mentors. We note below their achievements; we also asked them to describe a little of their backgrounds and practices.

Lifetime Achievement: Daniel J. Teague

His Background

Dan is an Instructor of Mathematics at the North Carolina School of Science and Mathematics (NCSSM), where he has taught since 1983. He received his undergraduate degree from the University of North Carolina at Chapel Hill, a Master's of Education from Springfield College, and a Ph.D. in Mathematics Education from North Carolina State University.

Dan has served as Second Vice President of the Mathematical Association of America (MAA) and twice as the Governor-at-Large for Secondary Teachers on the MAA Board of Governors. He is currently At-Large Delegate for the Board of Directors of the National Council of Teachers of Mathematics (NCTM). His committee work includes the National Research Council's Committee on Programs for Advanced Study of Mathematics and Science in American High Schools, two terms as a member of the U.S. National Commission on Mathematics Education, and the Advanced Placement Statistics Test Development Committee.

Dan was recognized with the Presidential Award for Excellence in Mathematics Teaching, the W.W. Rankin Memorial Award for Excellence in Mathematics Education from the North Carolina Council of Teachers of Mathematics, the University of North Carolina Board of Governor's Award for

Excellence in Teaching, and was twice recognized with the Distinguished Educator and Mentor Award by the College of Physical and Mathematical Sciences at North Carolina State University.

Dan was the section editor of "Everybody's Problems" in COMAP's newsletter for high school mathematics teachers, *Consortium*; is a co-author of the texts *Contemporary Precalculus through Applications* and *Contemporary Calculus Through Applications*; and recently was a member of the writing team for the *GAIMME: Guidelines for Assessment and Instruction in Mathematical Modeling Education*.

My Path to Mathematical Modeling

The North Carolina School of Science and Mathematics (NCSSM) takes pride in having a strong focus on mathematical modeling in its mathematics curriculum. The mathematical modeling emphasis began early in the school's history. NCSSM opened in the fall of 1981 with 134 high school juniors from across North Carolina. The curriculum was quite standard for the early 1980s when I was hired in January of 1983. NCSSM had the great fortune to have Henry Pollak, then head of the Mathematics Division at Bell Labs, as a member of its Board of Trustees. Dr. Pollak talked with the department about mathematical modeling; but since none of us had any experience with modeling, his excellent advice fell on willing but uninformed ears.

In the summer of 1984, I had the privilege of attending the first Woodrow Wilson Summer Institute in Mathematics, which was focused on Statistics and Quantitative Literacy. This summer changed my life and—after a few years—the mathematics program at NCSSM. One of the highlights of the summer was an evening talk by Henry Pollak. The combination of the sessions in the Institute by statisticians Dick Scheaffer and Stu Hunter and the presentation by Henry opened my eyes to what modeling could mean in a high school curriculum.

The final cog fell into place at the Joint Mathematics Meetings in 1986. Frank Giordano ran an MAA Mini-Course on mathematical modeling that I attended. I also attended the presentation by one of the 1985 MCM Outstanding teams on their solution to the Animal Population Problem, which presentation introduced me to the MCM. I finally understood what Henry had been saying! When I returned to school, I asked if I could teach a course in Mathematical Modeling as one of the first elective courses offered at NCSSM. In 1988, we had an Outstanding paper in the MCM ourselves, and the students presented their work at the Operations Research Society of America meeting that spring.

My understanding of the explanatory power of mathematical models was greatly enhanced by the opportunity to become part of the planning and instruction team for the Woodrow Wilson Summer Institutes in Mathematics for the next nine years. This allowed me to work with Henry for a

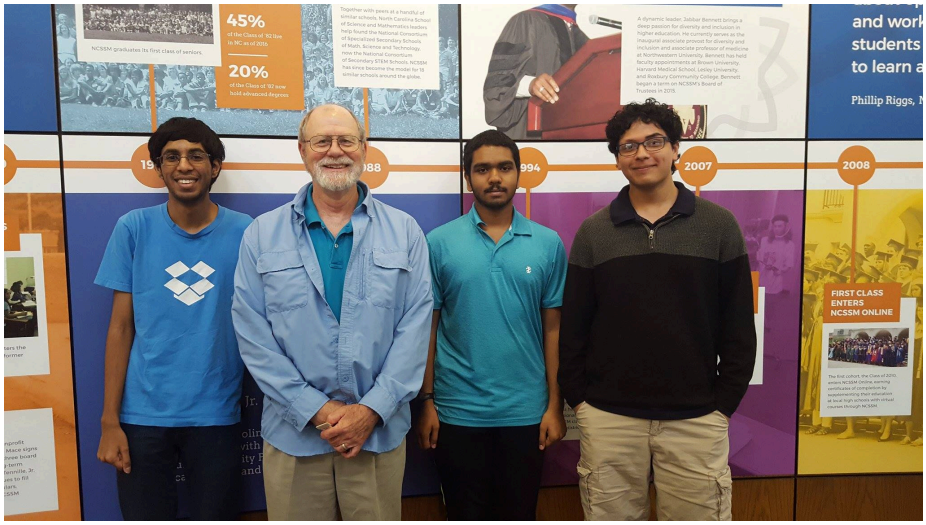
month each summer over a six-year span and to interact with mathematicians such as Sol Garfunkel, Steven Brahms, Peter Hilton, Jean Pederson, Bill Lucas, Tom Banchoff, and Joe Malkevitch, and mathematics educators such as Kay Merseth, Kathy Heid, Landy Godbold, Alan Schoenfeld, and many others. I have been extraordinarily fortunate to have had this unique opportunity to learn from master practitioners.

Since that first course, my colleagues and I have taught a course in mathematical modeling to over 1,500 high school students and had over 100 teams competing in MCM/ICM, HiMCM, and Moody's Mega Math Challenge. In 2016, we offered four sections of Mathematical Modeling to more than one-fifth of the senior class.

In addition to the formal course in modeling, we offer complementary electives in Modeling with Differential Equations, Introduction to Complex Systems (where students are introduced to agent-based models), the Structure and Dynamics of Modern Networks, and Advanced Probability Models.

An NCSSM team wrote its first MCM Outstanding paper in 1988, and teams from NCSSM have participated every year since then. In the past five years, my students have written seven HiMCM Outstanding papers and six MCM/ICM Outstanding papers (including two INFORMS winners, an MAA winner, and two Vilfredo Pareto Award winners), eight top-6 finalists in the Moody's Mega Math Challenge (including two First, three Second, and one Third Place teams), and one Outstanding team in the International Mathematical Modeling Challenge.

NCSSM students have many opportunities to develop mathematical models in diverse areas of interest. COMAP, through the materials produced and interactions with the talented staff, has played a significant role in the successes of our program.



Dan Teague with team members Nikhil Reddy, Sreeram Venkat, and Nikhil Milind of the NCSSM team that was Outstanding in the 2017 ICM Migration to Mars Problem.

Single-Year Achievement: Xiaofeng Gao

Her Background

Xiaofeng Gao received the B.S. degree in information and computational science from Nankai University, China, in 2004; the M.S. degree in operations research and control theory from Tsinghua University, China, in 2006; and the Ph.D. degree in computer science from the University of Texas in 2010. She is currently an Associate Professor with the Department of Computer Science and Engineering, Shanghai Jiao Tong University, China. Her research interests include wireless communications, data engineering, and combinatorial optimization. She has published more than 110 peer-reviewed papers and 7 book chapters in related areas.. She has served on the editorial board of *Discrete Mathematics, Algorithms and Applications*, and as peer reviewer for a number of international conferences and journals.

My Experience

I have been participating in MCM/ICM for the last 15 years. In 2003 and 2004, I entered the competition as an undergraduate student; in 2004, my team won a Meritorious Winner award for our solution to the Quick Pass Problem, which was the highest award among all Chinese teams. Earlier, I related the details of that experience and the next several years of competitions in this *Journal* [Gao, Wu, and Wu 2013].

Due to this experience, many of my friends came to me for advice about MCM/ICM, which pushed me to follow the MCM and ICM problems over years. In 2011, I became an assistant professor in Shanghai Jiao Tong University. From then on, I took on the role as a team advisor supporting students in MCM/ICM. In the first year, I had only one team, with three students from my lab; but gradually more students sought my guidance. By now, I have been an advisor for MCM/ICM for six years.

This year, among the teams that I advised were 6 Outstanding Winners and 1 Finalist (including two INFORMS Awards and one Leonhard Euler Award).

It is a great honor to receive the Doug Faires Award from COMAP, since it serves as an affirmation of my previous endeavor and also as encouragement for future work. Thus, in the following section, I would like to share some of my experience in guiding MCM/ICM teams, in the hope of benefitting advisors and students in the future.

Xiaofeng Gao with team members of her Outstanding and Finalist teams in 2017.

How to Guide a Team for the MCM/ICM?

Frankly, the secret of our success consists of only three words:

be *novel*, be *professional*, and be *beautiful*.

Be Novel, Like a Scientist

At the very beginning of the MCM in 1984, when Ben Fusaro proposed a new competition parallel to the William Lowell Putnam Mathematical Competition, he hoped that students would use mathematical tools to explore real-world problems.

Grasping the essence of MCM/ICM, contestants should view themselves as scientists searching for the solution to open-ended application problems rather than as students sitting through an exam. Hence, in considering the problem and writing the paper, students should show their understanding of the problem, their line of thought, and how they tailored their solution to the specific problem, instead of introducing some general solution and then explaining the results.

Specifically, undergraduate students in Shanghai Jiao Tong University usually have the opportunity to join research labs or join the Participation in Research Program to learn how to become a researcher. They are trained to face unsolved problems, read contemporary literature, discuss state-of-the-art research, and think individually and independently. Such training helps a lot to improve the novelty of their solutions.

For instance, Yiming Zhang, member of the Outstanding team on the Zambezi River Dam Problem (also the INFORMS Award Winner) said:

> I never thought that laboratory research could play a role in this contest. However, my actual experience proved that modeling and researching can be interlinked. When our team was designing the framework of the model, a paper by some researchers at Microsoft Research came to mind [Yuan et al. 2016]. I had read it earlier when working on the topic prediction problem for social networks. Its hierarchical and modular structure seemed quite suitable for this modeling problem. Thus, during the design of our model, I learned from its ideas and also from the authors' schematic style.

Another example is Zhiying Xu, member of an Outstanding team on the ICM Airport Security Problem (also the Leonhard Euler Award Winner). She said:

> Most students easily think of cellular automata or a queuing model for the Airport Security Problem, which are dreary, clichéd, and lack novelty. However, I did research on multicast in ad-hoc networks in my sophomore year in the lab of Industrial Internet of Things (IIOT) at Shanghai Jiao Tong University. I read a lot of papers about scheduling optimization during that period. Although it was a year ago and my research focus has changed since then, the idea of Lyapunov optimization and the back-pressure algorithm [Neely 2010] dawned on me. Although the background was very different, the problem was essentially similar. Thus, I adapted these models and got an excellent result.

Novelty is one of the most important issues that makes a team stand out above the rest.

Be Professional, Like an Analyst

After the model construction, you've just finished only one-third of the task! The next step should be explaining the "superiority" of your design. Problem clarification, assumption justification, and model explanation are the first and foremost things to discuss. Next, theoretical proofs, numerical tests, visual analysis, sensitivity tests, case studies. . . : Many methods could be adopted to support your idea. The bottom line is to provide evidence for your approach.

At this point, you should be professional, like an analyst: Prove the efficiency, effectiveness, and priority of your approach, using any available means. Also, the negative points—including the things that you cannot accomplish, the future work that you may consider, and the weaknesses of your model—should all be carefully evaluated in your solution paper.

For instance, Yisen Yao, member of the Outstanding team on the Zambezi River Dam Problem (also the INFORMS Award Winner) said:

> Before entering the MCM/ICM Contests, I considered building the model as the most difficult step. However, after the competition, I

> realized that there is not a single gold standard for the model, as long as you can make a strong case for your solution. It is the process of collecting data, solving model formulas, and running simulations that makes all the difference. Facing great quantities of formulas and numbers, it is a huge challenge for participants to summarize their models with concise words and reasonable formulas. For example, in this contest, we used a wide range of data sources, such as sea-level maps from Google Earth and the data of average precipitation from the Zambezi River Authority. Additionally, we used MATLAB for our simulation, which makes our result more accurate and credible.

In other words, after the model construction, the most important thing is analysis and justification.

Be Beautiful, Like an Artist

Third, a good solution paper should be treated like a work of art. You should write the paper like an artist, paying attention to every possible aspect, especially the organization, the visualization, and the presentation.

For example, Duxing Hao, member of the Outstanding team on the Migration to Mars Problem (also the INFORMS Award Winner), said:

> When it comes to the highlights of our paper, illustration should surely be the first. Given our paper's title ("Society Planning: Model, Simulation and Visualization"), we spent lots of time on "visualizing" numerical results [see **Figure 1**.]. Our principle is that by reading the summary part and just the images, readers should be able to grasp the idea, the model, and all essential results of our paper. To the basic caption for a figure, we added direct conclusions from the figure and pointers to corresponding paragraphs giving detailed discussion. These reader-centered features really helped in organizing our paper and clarifying the structure. Besides, one should always read published articles in the relevant research area and imitate their figure styles and paper organization as much as possible.

Every part matters in the contest: not just the main body, but the title, the abstract, the outline, the references, and if required, the letter, advertisement, or nontechnical report. In the Judges' Commentary on the Space Junk Problem in 2016, Catherine A. Roberts said: "Meritorious paper 47676 from Shanghai Jiao Tong University was the exemplar in regard to citations" [Roberts 2016] (Team 47676 was also one of my teams that year). This shows that every detail may leave a deep impression on the judges, bringing more possibilities of the Outstanding award.

Be novel, be professional, and be beautiful. I hope that in the future, more students and advisors will participate in this intellectually challenging yet rewarding competition and enjoy their journey.

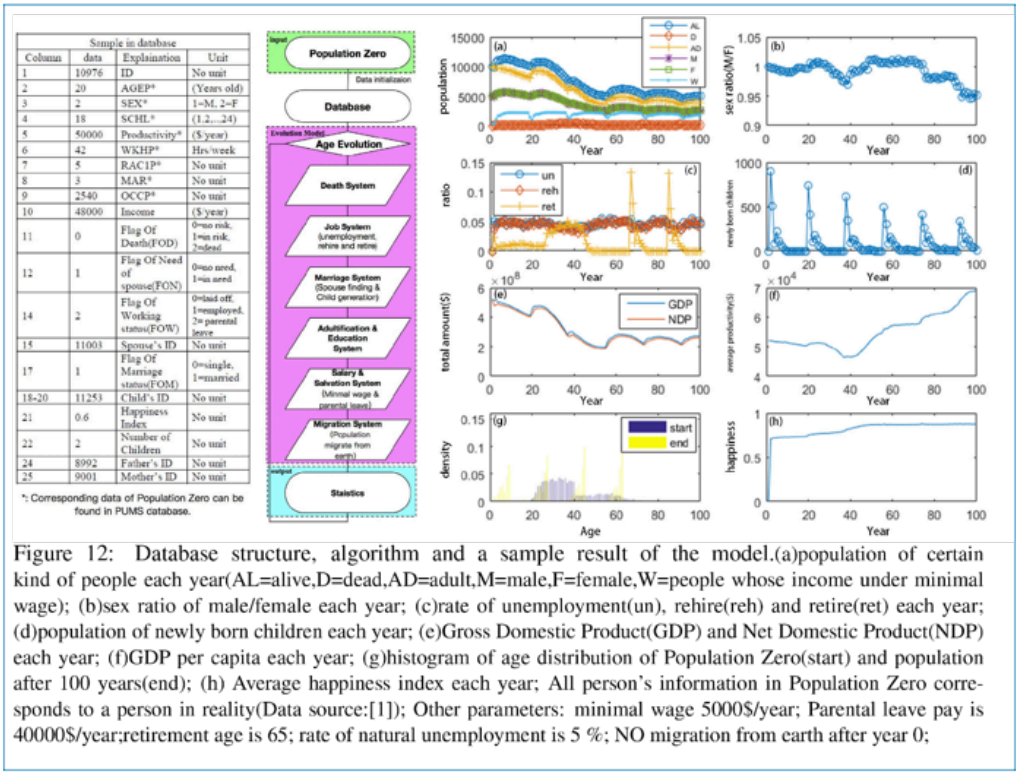


Figure 12: Database structure, algorithm and a sample result of the model.(a)population of certain kind of people each year(AL=alive,D=dead,AD=adult,M=male,F=female,W=people whose income under minimal wage); (b)sex ratio of male/female each year; (c)rate of unemployment(un), rehire(reh) and retire(ret) each year; (d)population of newly born children each year; (e)Gross Domestic Product(GDP) and Net Domestic Product(NDP) each year; (f)GDP per capita each year; (g)histogram of age distribution of Population Zero(start) and population after 100 years(end); (h) Average happiness index each year; All person's information in Population Zero corresponds to a person in reality(Data source:[1]); Other parameters: minimal wage 5000$/year; Parental leave pay is 40000$/year;retirement age is 65; rate of natural unemployment is 5 %; NO migration from earth after year 0;

Figure 1. The visualization example from Duxing Hao's team for the Migration to Mars Problem.

Acknowledgement

I give my sincere thanks to all Outstanding and Finalist teams from Shanghai Jiao Tong University, including:

Team 55280: Yiming Zhang, Jiachen Sun, Yisen Yao (Outstanding Winner and INFORMS Award Winner for the Zambezi River Dam Problem)

Team 57659: Xiangyu Liu, Zhenghui Wang, Xiwei Hu (Finalist for the Zambezi River Dam Problem, with advisor Prof. Yishuai Niu)

Team 55583: Junhao Xu, Tianling Bian, Qinghao Liu (Outstanding Winner and INFORMS Award Winner for the Self-Driving Cars Problem)

Team 55278: Jiefeng Chen, Qi Li, and Yu Shi (Outstanding Winner for the Self-Driving Cars Problem)

Team 55585: Qinghao Mao, Zhanghao Wu, Junpeng Hu (Outstanding Winner for the Self-Driving Cars Problem)

Team 55295: Zhiying Xu, Peitian Pan, Xiaoxing Wang (Outstanding Winner and Leonhard Euler Award Winner for the Airport Security Problem)

Team 55285: Yikai Huo, Zhiyu You, Kan Chang (Outstanding Winner for the Airport Security Problem)

Team 55491: Yunyi Yang, Xiaoqing Geng, Baicheng Xiang (Finalist for the Sustainable Cities Problem)

Team 64486: Duxing Hao, Hao Yu, Yitong Ou (Outstanding Winner and INFORMS Winner for the Migration to Mars Problem, with advisor Prof. Yishuai Niu)

Solomon Garfunkel of COMAP presenting the Doug Faires award to Xiaofeng Gao at Shanghai Jiao Tong University, June 15, 2017.

The Future

The Doug Faires Award will be given to individuals who achieve great results in a particular year or attain cumulative excellent results over a period of time. Xiaofeng Gao and Dan Teague exemplify the goals of the Doug Faires award. Awardees receive a certificate of appreciation that expresses our enduring gratitude.

We would like you to nominate someone in your community (including possibly yourself!) who is promoting mathematical modeling at the local level.

References

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