# The BIG Newsletter

Volume 19, Issue 2, Fall 2023

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

---

**In this issue:**



## Message from the Chair

Greetings BIG SIGMAA members,
I hope you had a restful summer and, if you are in academia, that your fall semester is going well.

To many of us BIG SIGMAA has been a place to learn about, and share our interests in, mathematics in the real world. As an undergraduate who loved mathematics, I did not know what I could do with a degree in the field, except to teach. I knew I did not want to teach at the school level, so I decided on going to graduate school to be able, eventually, teach at the college-level.

I was always interested also in careers in industry, but I did not know how to combine my two passions in one place. Few years into my graduate studies I learned of jobs like consulting. It was too hard for me to get into those, plus I still wanted to pursue my Ph.D. The point I am trying to make is that many of our students may be in the same situation: they love mathematics; they have the critical thinking skills; the attention to details; the problem-solving skills…etc. And the only career route they know of is graduate school or teaching at middle/high schools. We all know that is not true anymore, and for some of us, we may need to make our students aware of that, and to do it while they are still undergraduates.

BIG SIGMAA is a place where you can network with those of similar interests. Our sessions at JMM and MathFest have included presentations on work in BIG, ranging from experienced professionals in non-academic careers to students working on projects, internships or research in BIG. Great ideas were shared by PIC Math participants, or faculty who created internship opportunities for their students, and faculty who mentored students in BIG research projects.

In addition to BIG SIGMAA and PIC Math, the BIG Math Network is a third venue with similar interests. These three groups, in my opinion, complement each other. PIC Math provides faculty with the training needed to create a research course on their campus where students experience working on a real-world problem from BIG. BIG Math Network provides resources for departments and students, and conducts informative webinars. Our SIGMAA provides a forum for communication and networking with professionals who have the same interests.

*Continued on page 19*

## Interviews with Michelle Ghrist and her students

Michelle Ghrist earned bachelor's degrees in mathematics and physics from the University of Toledo and an MS and PhD in Applied Mathematics from the University of Colorado at Boulder. She is currently an Associate Professor of Mathematics at Gonzaga University, where she was Director of the Applied Mathematics Program from 2019-2022 and the inaugural faculty advisor for Gonzaga's new Student SIAM Chapter from 2020-2022. Her past jobs include serving as Professor of Mathematical Sciences at the U.S. Air Force Academy from 2002-2017, which included spending a sabbatical year as an analyst for Air Force Space Command in 2010-2011, and teaching at Belmont University from 2000-2002.

Michelle's primary research area is numerical analysis of differential equations, but she is also interested in mathematical modeling, connecting mathematics and the humanities, and various pedagogical efforts such as utilizing alternative assessments and designing technological tools to enhance student learning. She enjoys introducing undergraduates to mathematical research; in addition to mentoring several students at the Air Force Academy, eleven Gonzaga students have done undergraduate research projects with her, presenting their work at various national and regional conferences.

**What lessons did you learn while working as an analyst for Air Force Space Command during your sabbatical in 2010-2011?**

I was fortunate that four of my mathematics colleagues had previously done their sabbaticals there, doing work on GPS satellites. As I was starting my yearlong stint, one of them gave me great advice: "You may frequently feel like you aren't contributing that much to the ongoing work, as about 90% of your time will be spent learning, and only about 10% of your time will be contributing. This is perfectly normal – don't feel like you must always be contributing."

One of my early challenges during this time was that my areas of mathematical expertise were quite different than those four colleagues, so even though I was learning a lot, I couldn't see how I could contribute anything in the area of GPS. At a brownbag seminar about two months into my sabbatical, I met some people working in a different area, missile warning and defense, and immediately connected with their work. In the end, I contributed significantly to two projects with this group and one project with the GPS group. Through this, I learned the importance of continuing to expand your horizons; just because others have done things a certain way doesn't mean that your pathway needs to follow theirs – be open to new possibilities that come your way. Also, attending seminars can be invaluable to opening doors!

I also learned that many real-world problems don't necessarily require advanced mathematical techniques. What is important is to have a flexible approach to problem solving: knowing what kinds of mathematics are appropriate for a given problem and being able to try out and reconcile the results from many different approaches. Learning how to frame open-ended problems is a key skill that we need to better develop in our students – in the classroom and through research.

**What are some of your more creative endeavors as a math professor?**

As a new math professor at Belmont University in 2000-2002, I embraced the opportunity to combine my loves of mathematics and the humanities. My Basic Concepts of Mathematics students and I produced a mathematical art show: "Images from a Philosophical Discussion of Mathematics". For several semesters,

my College Algebra students created mathematical art and composed mathematical songs and poems. I also taught an Honors Seminar on Mathematics in Prose and Poetry; these students and I produced a mathematical play of skits and songs entitled "MathTV: A curiously funny mathematical production – Musical, Aesthetic, Taboo, Humorous, Entertaining Mathematics All Together in Chaotic Skits." These efforts led me to organize a contributed paper session at MathFest 2008: "Incorporating Humanities and the Arts into the Mathematics Classroom (and Vice Versa)".

While there were less opportunities for such endeavors at the Air Force Academy, I still frequently brought in my flute and piccolo to demonstrate Fourier series and transforms by using a real-time FFT analyzer. I also taught and led an evening presentation on mathematics and music for students and their parents at an on-base elementary school.

At Gonzaga, I recently taught an Honors core integration seminar on Quantitative Literacy to students pursuing a wide variety of majors.

**Tell me a little bit about your connections with Pi Mu Epsilon (the national honorary mathematics society).**
I was inducted into PME as an undergraduate at the University of Toledo. Soon after I arrived at the Air Force Academy, I restarted the Colorado Gamma chapter of PME there. In 2008, I was extremely surprised when PME awarded me the inaugural PME Faculty Award (given triennially) for service to PME and promoting scholarly activity among undergraduates. Since joining Gonzaga in 2017, I have assisted with the Washington Epsilon chapter of PME.

From 2020-2023, I served on the PME National Council as Secretary-Treasurer; while this was an incredible amount of mostly behind-the-scenes work to keep things running, I greatly enjoyed getting to know many dedicated colleagues who are working to improve opportunities for undergraduates in mathematics. I have great respect for the mission of organizations like PME and SIAM and for my colleagues who volunteer their time as chapter advisors, council members, and advisors of student research projects.

**What are some of the benefits for students doing undergraduate research?**
There is a creative open-ended side to problem solving and mathematics that many students never get to experience. Textbooks often present "canned" problems that we already know how to solve; what happens when someone isn't telling you exactly what to do next or even what kind of mathematics is even appropriate to apply to a given problem? How can we approach a problem analytically, numerically, graphically, etc. and try to understand the results that we get? Research offers students a taste of this experience, of being allowed to think independently, and many find it exhilarating – and frustrating at times, but that makes the discoveries and breakthroughs that much sweeter.

Being able to explain complex technical communication to a wide variety of audiences is an incredibly important skill. How can I distill down this information to the essentials for my boss, for my clients, or for the general? How can I logically and succinctly elucidate what I have done? Giving conference presentations and writing theses, with multiple rounds of editing, give students valuable opportunities to develop these skills as well as other key skills such as LaTeX and programming.

Another key benefit is learning the value of failure; I often tell students that about 90% of what I try in research ends in failure, or in limbo (postponed for later?), and there is nothing wrong with that! There is value in what may seem like a dead end; often those pathways illuminate new questions and possibilities that you haven't even considered when you started the project. As a society, failure often has a negative

connotation, but when you are on the frontier, there will be many fits and starts – it's how we make progress! In addition, it's amazing what your subconscious can come up with, given enough time to ponder ideas (and, of course, hard work to become familiar with a topic).

**What other interests do you have besides math?**
I enjoy playing flute, hiking, and reading a wide range of books. I also enjoy doing jigsaw puzzles and playing a variety of board, word, and logic games. During my sabbatical this year, I am challenging myself by playing flute with the Gonzaga Symphony Orchestra and by auditing an Italian class.

**Jonah Reeger** is an Assistant Professor of Mathematics, Department of Mathematics and Statistics, Air Force Institute of Technology (AFIT). He completed a BS in Mathematical Sciences at the United States Air Force Academy, a MS in Computational and Applied Mathematics at Rice University, and a PhD in Applied Mathematics at the University of Colorado at Boulder. Jonah served as an active-duty member of the United States Air Force for eleven years, working on technical solutions to some challenging problems relevant to the Department of Defense. He has held research positions in federal civil service at the Air Force Research Laboratory and served as faculty at both AFIT and the United States Naval Academy. Most of his free time is spent enjoying the outdoors with his wife and two children.

**How did doing undergraduate research impact your trajectory and/or how you view mathematics?**
Performing undergraduate research was a life-altering experience. I had originally planned to complete graduate work in the field of economics, but an extended research project highlighted how much more interesting the investigations in mathematics can be. Given the opportunity to explore an open problem in the stability of numerical methods for initial value problems, I had the chance to consider both computation and proof. These explorations helped me learn how much more I enjoy investigating the computational aspects of a problem, which is what I am still interested in today. I also had the opportunity to become familiar with the work of my future doctoral advisor, which made selection of an advisor much easier when I approached that opportunity.

**What are some of the benefits of doing undergraduate research?**
Undergraduate research provides student opportunities that are typically not available in coursework. The problems that appear in texts or the typical class project are well known with established techniques for obtaining solutions. Research, on the other hand, often tackles questions that are potentially well-known, but without any (satisfying) processes for obtaining answers. Learning how to even begin to approach these questions is fundamental to any career in industry or academia, even if it is not research-focused, as most real-world problems do not have a solution that appears in the back of a text. Research will not only teach you how to think about the project you are working on; it will teach you how to think about the way you manage problems in the future. Further, if you have interest in pursuing a graduate degree in mathematics, then it is a great way to be exposed to prominent researchers in the field that might make great graduate advisors in the future.

**What advice do you have for a student who is considering doing undergraduate research?**
Find a project that is challenging, and search for an advisor that can provide you with the time and freedom to investigate. The problems that are the most fun and most rewarding to tackle, although often frustrating, are those that require you to evolve your way of thinking and working. Advisors have a

profound impact on how much you learn during a project and how enjoyable the research process can be. Seek out a faculty member that you respect and are comfortable working closely with, and the experience should be a great one.

In 2020, **Alana Dillinger** was the first student to graduate from Gonzaga University with a major in Applied Mathematics. During her time at Gonzaga, she worked on numerical methods research with Dr. Michelle Ghrist, exploring different multistep methods and their stability. She worked at the Bank of New York Mellon as an analyst before joining Twin Cities In Motion, where she plans running races as an event coordinator.

**How did doing undergraduate research impact your trajectory and/or how you view mathematics?** Doing undergraduate research helped me develop my critical thinking skills and taught me how to be curious about mathematical problems which have not yet been solved. Getting to work on discovering numerical methods is what inspired me to pursue an Applied Mathematics degree. I enjoyed the application of the theory I had been learning and would not have had that opportunity without research. My view of mathematics changed quite a bit; it became much more approachable to me knowing that even as an undergraduate I was able to work on new research. Anyone is capable of furthering our knowledge of math; it just takes curiosity and a great mentor to keep you headed down the right path.

**What are some of the benefits of doing undergraduate research?**
Doing undergraduate research is such a great addition to any degree! It teaches you to apply what you've learned in your classes in a new way and put together everything you've learned to come up with new ideas. Writing research papers also takes a unique skill set that is difficult to learn otherwise. Math can be such a technical field and being able to write down your work in a way that others can understand is challenging. By doing research, you can hone your technical writing skills and learn to communicate rather complicated ideas to different audiences. Being able to communicate your work is so important when you enter the workforce so you can share your work with others. In addition, research offers opportunities to present at conferences. Here you can practice your public speaking skills and again practice how to put complicated ideas into language that others not close to your work can understand. Participating in conferences is also an amazing way to network with the mathematics community. Having the opportunity to attend conferences is such a simple way to get to know others in the field that you enter after graduating. You can never have too many connections!

**What advice do you have for a student who is considering doing undergraduate research?**
Do it! If you are afraid that you don't know enough or don't have the skills to do research, you are not alone. I had terrible imposter syndrome but found the courage to ask anyways, and it was so worth it. You're not meant to know everything before starting research; it's another opportunity for you to learn. The professors are there to mentor you and want to help you grow through research projects. If you are in a class that you wish was more in depth or find a professor whose work you admire, ask them about research opportunities. It will be challenging but so rewarding!

**Matthew Rhilinger** received his bachelor's degree from Gonzaga University in 2022, majoring in Applied Mathematics with a minor in Physics. He is currently in the Mathematics PhD program at Colorado State University in Fort Collins, Colorado.

**How did doing undergraduate research impact your trajectory and/or how you view mathematics?**
The opportunity to do research in my undergraduate years was the single most impactful experience in my journey to graduate school. As I started my degree, math was fun, but it was not clear what the word "research" meant in this context. Research seemed exclusive to performing experiments and obtaining empirical data to analyze. Being able to contribute to the research done by Dr. Ghrist opened my eyes to the vast questions that could be answered by math, and that these questions have real world implications.

**What are some of the benefits of doing undergraduate research?**
I think learning to run with the ideas that come when working on a problem is a very important skill that I took away from research. No matter how silly you think the idea is, it might just lead you down the right path. Or maybe it will not, but chances are you will learn something important along the way.

**What advice do you have for a student that's considering doing undergraduate research?**
It is so worth it. I had my reservations at first, but it is the best decision I made in undergrad. 100% go for it. As for how to go about finding a topic and professor to work with, talk to every professor in the department who is doing research that you think might interest you. Every professor I have come across absolutely loves to talk about their research interests because they are so passionate about it. After doing that, you should have a good idea of what sounds the most interesting to you.

**Ben Lombardi** is currently a first year PhD student in Applied Mathematics at the University of Colorado at Boulder. He graduated from Gonzaga University in 2023 with a BS in Applied Mathematics with a concentration in Economics and a minor in Computer Science, where he was involved in research with numerical methods for approximating solutions to differential equations for three years.

**How did doing undergraduate research impact your trajectory and/or how you view mathematics?**
Doing academic research ended up confirming that I wanted to go to graduate school. I really ended up having a passion for research, and this early opportunity to do research let me structure my undergraduate experience to prepare for graduate school.

**What are some benefits of doing research?**
Doing research is a lot of fun. Not only to you get to explore and learn math outside of the classroom, but you get to practice your technical writing and communication skills which are useful regardless of what profession you choose in mathematics. Also, it is pretty fun to go and present at conferences.

# Interviews with Vinodh Chellamuthu and his students Heather Smith and Matthew Gergley

Vinodh Chellamuthu is an Associate Professor of Mathematics at Utah Tech University in St. George, Utah. He is committed to promoting the quality education of future scientists by creating opportunity channels for career development through high-impact teaching and research pedagogy. He has mentored numerous undergraduate research projects sourced from Business, Industry, and Government Agencies. He has guided numerous research projects, including predicting visitation trends at Zion National Park and developing control mechanisms to prevent the spread of zoonotic diseases. These projects have originated directly from Business, Industry, and Government Agencies. As the curriculum developer and program coordinator of the B.S. in Applied and Computational Mathematics degree at Utah Tech, he has fostered undergraduate research opportunities through collaborations with local businesses and industries. His work with students has been supported by several grants, including those from MAA's PIC Math, NREUP, and the CURM minigrant. His research interests lie in Mathematical Biology, Mathematical Modeling, Differential Equations, and Industrial Mathematics. During his tenure at Utah Tech University, he has mentored over 45 undergraduates in 28 research projects. These projects have led to more than 100 presentations at various conferences, earned several awards for outstanding student presentations, and resulted in five publications in peer-reviewed journals. In recognition of his success as a teacher-mentor, he has been honored with the Early Career Mentoring Award from CUR, the 2022 Henry Alder Award for Distinguished Teaching, the 2019 Distinguished Teaching Award from the MAA's Intermountain Section, and a Distinguished Teaching Award from Utah Tech University. Currently, he serves in several positions at the national scale, including as a councilor on the Council on Undergraduate Research, Vice-Chair of Programs for BIG SIGMAA, Program Coordinator for UR SIGMAA, and Past Chair for the MAA Intermountain Section.

**What attracted you to the PIC Math program?**

It was due to its strong emphasis on applied learning and its direct relevance to real-world industrial problems. As someone deeply involved in educational development, particularly in designing a new B.S. program in Applied and Computational Mathematics, I was looking for curriculum design opportunities to provide our students with a more holistic, practical education that goes beyond theoretical understanding. When I learned about PIC Math through my mentor, Dr. Michael Dorff, via the MAA Early Career Network, I immediately saw the value it could bring to our curriculum. The program's approach to solving genuine industrial problems allows students to appreciate the applicability of their mathematical skills, thereby making their academic journey more meaningful and motivating. Additionally, the interdisciplinary and collaborative nature of these projects equips students with the teamwork and communication skills they'll need in their careers. Furthermore, the networking aspect of the program is invaluable. Being able to connect students with professionals in the industry not only opens up potential internship and employment opportunities but also gives them a clearer understanding of what to expect post-graduation. In summary, PIC Math offers an excellent balance of applied learning, skill development, and professional networking opportunities, making it an ideal fit for our curriculum and students.

**Can you tell us more about the applied and computational mathematics curriculum and how the integration of the PIC Math Program into the Curriculum worked out?**

The curriculum for our Applied and Computational Mathematics program is meticulously designed to align with our polytechnic theme and its "Active Learning, Active Life" motto. We offer a diverse array of

courses that span across science, technology, engineering, business, and finance, preparing students for an extensive range of rewarding career paths. The curriculum has been evolving to be increasingly cross-disciplinary, reflecting the complex needs of today's job market. Incorporating the PICMath program into our curriculum has been a pivotal move. The PICMath program has also been instrumental in enhancing our undergraduate research experiences, which directly feeds into our goal of creating a learning environment that is both active and applicable to real-world problems and contributed to an increase in the number of mathematics majors and facilitate the formation of a focused mathematics learning community. Moreover, it has sparked a heightened interest in industrial careers among our students by providing them with practical, applied research experiences.

**Can you tell us about some highlights or main features of your Math 4800 course experience? How many times did you run it? How many students were involved?**

I've had the opportunity to teach our Math 4800 course seven times, involving over 35 students in projects that tackle real-world issues specific to the Southern Utah region. Through this course, students have addressed a range of complex, interdisciplinary problems. For example, they've forecasted the number of hikers visiting Zion National Park, worked on redistricting zones for the Saint George Police Department, and analyzed data trends for the auto industry using statistical models.

**What would you recommend to other faculty who want to incorporate similar experiences into their school's curriculum?**

I would highly recommend other faculty to take the initiative in incorporating similar experiences into their school's curriculum. Don't be daunted by the administrative or logistical hurdles that might initially appear. Step beyond the familiar boundaries of regular classroom teaching and actively seek connections with local industry professionals. This engagement offers a rich source of real-world problems that can be adapted into challenging and relevant mathematical exercises for students. Not only does this approach benefit students by providing them with authentic learning opportunities, but it also revitalizes faculty members' own teaching and research endeavors. To make the process less intimidating, start by researching the existing literature on the benefits of Undergraduate Research or similar hands-on methods for both students and faculty. Once equipped with this information, it becomes easier to garner institutional support for proposed changes. The effort is more than worth it, and I can assure you that it's a rewarding journey for both professors and students alike.

**What did your students do after finishing Math 4800 and the PIC Math? Did the experience affect their careers?**

I'm thrilled to share that the approach of incorporating real-world challenges into the curriculum has proven to be incredibly beneficial for my students. Nearly all have gone on to either graduate school or lucrative careers in high-demand fields such as data science and the financial industries. One common thread that has contributed to their success is the skill set developed in solving interdisciplinary problems in a real-world context. By having the opportunity to apply classroom theories to tangible challenges, students gain a unique set of competencies highly valued by employers. This hands-on approach has not only made the learning experience more engaging, but it has also provided them with the practical skills needed to excel in their chosen fields. The ability to use academic learning as a tool for solving complex, real-world problems has given them a competitive edge in landing meaningful and well-paying jobs.

**What piece of advice would you give a student who isn't sure of what they want to do yet?**

If you're uncertain about which career to pursue, it may be beneficial to explore a wide range of options. You can do this by enrolling in courses from various disciplines, participating in a variety of extracurricular activities, and taking on internships in different sectors. Such experiences will help you pinpoint your

passions and talents, which in turn will assist you in making a more informed career choice. Often, realizing what you don't enjoy can be just as valuable as identifying what you do enjoy. Both are important steps in the learning journey toward finding a fulfilling career.

**What would you recommend professors to do to prepare their students for a career in the BIG sector?**
For math professors aiming to prepare students for careers in the Business, Industry, and Government (BIG) sector, incorporating real-world applications into the curriculum is recommended. Focusing on case studies and projects that simulate challenges in areas like data analytics, risk assessment, or optimization problems commonly encountered in BIG can be particularly beneficial. Additionally, emphasizing the use of software tools and programming languages such as R, Python, or SQL, which are widely used in these sectors, can equip students with the skills they need. Networking is also crucial; inviting industry professionals for guest lectures or arranging site visits to industries can expose students to the practical aspects of the field and allow them to make valuable connections. Lastly, soft skills like communication and teamwork should not be overlooked, as they are highly valued in the BIG sector. By blending theoretical knowledge with practical skills and industry exposure, students can be better prepared for successful careers in this diverse and dynamic field.

**What would you say is the most important skill that one needs to work in the BIG?**
The key skill for success in the BIG sector is adaptable analytical and lateral thinking. This means not just mastering data analysis and technical tools, but also understanding the wider context of problems and effectively communicating solutions**.**

**Heather Smith** is a senior mathematics major and computer science minor. She works with the STEM Outreach Center to provide younger students with fun ways to explore and learn STEM subjects. She participated in the Industrial Careers in Mathematics course supported by the PIC Math Program and was kind enough to answer several questions for the BIG SIGMAA Newsletter.

**What attracted you to take Industrial Careers in Mathematics?**
I enjoy opportunities to apply my current knowledge and skills and learn more as I solve problems. I am exploring what I want out of a career in Mathematics and this class is an amazing way to experience what a business problem might be like.

**What project(s) have you worked on?**
My team and I provided Zion National Park with a method to predict visitor counts, daily and hourly, to certain hiking trails using past data.

**Can you briefly describe how you approached the project?**
We modified a mathematical algorithm developed for weather prediction. The weather is roughly the same around the same times each year, and so are visitors to Zion National Park, so it was interesting to see similar outcomes using the same method. We also spent some time exploring the data and considering how to deal with missing data.

**What do you find to be the main highlights or benefits of the experience provided by Industrial Careers in Mathematics?**

It was great to work on a team with people from different disciplines on a local problem. We learned how to research, apply mathematical concepts, work with data, work as a team, and communicate our results. I am grateful for the experience.

**How has your attitude towards math changed as a result of this project?**
I can see how mathematics can give us a better understanding of the world around us. We can see patterns we wouldn't know without math, data, and programming, and use that information to make positive changes. It is also encouraging to see how solutions to one problem might solve others with some adaptation.

**How have your plans for the future changed as a result of this project?**
I am more interested in working with data, which I hadn't really considered before. I plan to continue my education in data analysis.

**Matthew Gergley** is a senior at Utah Tech University with a major in Mathematics. He is interested in Applied Mathematics. He was kind enough to answer several questions for the BIG SIGMAA Newsletter.

**What attracted you to take Math 4800: Industrial Careers in Mathematics?**
The decision to take Math 4800: Industrial Careers in Mathematics was because my Mathematical Modeling professor recommended that it would be a good experience to work with an industry in the area. I was very interested in being able to work on a real community problem using the tools of mathematics.

**What project(s) have you worked on?**
The project I worked on in this course was optimizing Santa Clara/Ivins Police Department patrol routes and scheduling. Can you briefly describe how you approached the project(s)? I approached the project in more of a data analytics way to see what we had to start with and then use mathematics and visuals of the mathematics to convey a solution.

**What do you find to be the main highlights or benefits of the experience provided by Math 4800?**
I really enjoyed being able to collaborate with a real world industry liaison and work in a small group of like minded individuals with a great faculty mentor. It was a challenging project but very rewarding upon completion.

**How has your attitude towards math changed as a result of this project?**
It opened my eyes to more ways that mathematics could be applied to various fields and problems that you might think have nothing to do with mathematics. It showed me the seemingly limitless applications of mathematics.

**How have your future plans for the future changed as a result of this project?**
My plans for the future have not changed but rather enhanced my interest in mathematics.

**What are your plans now?**
My plans now are to continue my education in mathematics and apply to graduate school to get a PhD in Mathematics and further research mathematical neuroscience.

**Interview with Maila Hallare, United States Air Force Academy**

Maila Hallare is an Assistant Professor of Mathematics at the United States Air Force Academy. She currently serves as the Editor-in-Chief of the CODEE Journal and the Mathematica Militaris. The mission of the CODEE (Community of Ordinary Differential Equations Educators) Journal is to promote the teaching and learning of differential equations while the mission of the Mathematica Militaris is to support the mathematics faculty and students of the nation's service academies. In this conversation, we talk about Dr. Hallare's first foray on mentoring undergraduate research projects, her past and current students' research projects, how she supports under-represented groups in mathematics to promote inclusion and diversity, and her overall mentoring and teaching philosophies.

**How did you get into mentoring undergraduate research projects?**

After obtaining my PhD in Mathematics from the University of Kansas, the only academic job that I could find was a teaching position in a community college in a city that is within driving distance of where my husband had found employment. Before my first semester ended, a female certified nursing assistant student in my Pre-calculus class approached me and expressed a desire to do a research project that would build upon the topics that we covered in class. This was unfamiliar territory to me. Since it was my first academic job as a "Dr." and I was truly honored that the student chose me, I said, "Yes, sure! Let's do this." But then anxiety and my imposter syndrome kicked into high gear… How can I find topics that are suitable for the student? Would solving the most-difficult end-of-the-chapter questions from our textbook be good enough? Since I do not know anything about nursing, how can I find topics that she would be interested in? Should I write a syllabus for her research plan? Since research is not part of her curriculum, how would we meet and how would I assess the quality and progress of the project? Am I even qualified to be a research mentor?

In the end, the student completed a project that performed curve-fitting on tidal cycles and biological rhythms. She was not able to do presentations and publications on her research work but I believe that her research experience helped her in winning a scholarship for nursing school. As for me, my Dean was quite pleased that I mentored a community college student's research project. Truth be told, I was exhausted from the experience… but I was hooked. I wanted more opportunities for mentoring and research. I had to go find employment in a university where mathematics research or capstone is a program requirement.

**How did your interest in mentoring undergraduate research shape your career?**

I was not able to find a university position right away and most community college students were not interested in research. Fortunately, I found myself being involved in the local science and engineering fair for high school students. I volunteered as a judge and as a mentor (in an advisory capacity only) to as many projects that I could get my hands on. Although most of these high school projects were not in the area of differential equations, I benefitted from the experience by staying current with what high school students think and by improving my communication skills. The latter was quite important because I did not have any experience with K-12 education in the United States. I was also beginning to see that being involved in student research projects would pave the way for my own return to research publications.

**How can mentoring undergraduate research projects address under-representation?**
Before getting my current job at the United States Air Force Academy, I was able to get a position at a local historically-black college/university (HBCU). My first research student in this HBCU was under-prepared in mathematics and because of this, the research mentoring process was painful and exhausting. At the end of my first year in that HBCU, I had to do an intentional reset and reflection of my mentoring goals and philosophies. The main lesson for me was that I have to tailor my research guidance in order to meet where the students are. I was reminded that a research project was not about me and my plans of publishing our research products. In my subsequent years at this HBCU, I gained mentoring strength along the way, guiding every one of my student to focus on improving their soft skills and building their mathematics confidence. I found that building confidence maybe achieved by setting high but realistic expectations, providing encouraging feedback, and celebrating small wins. I believe that the students feel empowered when they showcase their hard work and see their research deliverables such as research posters, presentations, and publications.

**What kind of research projects have you mentored or are currently mentoring?**
My PhD training was leaning mostly on the "pure" side of differential equations but almost all of my research mentees have completed "applied" and interdisciplinary projects on mathematical modeling via differential equations. Some of the projects in this area include work on cancer growth and treatment (virotherapy and radiotherapy), ecosystems-based fisheries management, wireless power transfer, spread of innovation, and vegetation-erosion dynamics. (In some of these projects, I teamed up with a friend from a nearby predominantly-white university (PWU), Dr. Iordanka Panayotova, and together we co-mentored group research projects between my HBCU students and her PWU students. Our research community was able to help create some connections between our universities.) I've also had some students worked on topics that do not involve differential equations, namely, quantifying racial disparities on health issues, and mathematically producing airfoils. Currently, I have a student working on investigating survival regimes when cannibalism and necrophagy happen under extreme energy limitations, another one on language dynamics and coexistence of competing languages, and a project on modeling immunotherapy and melanoma.

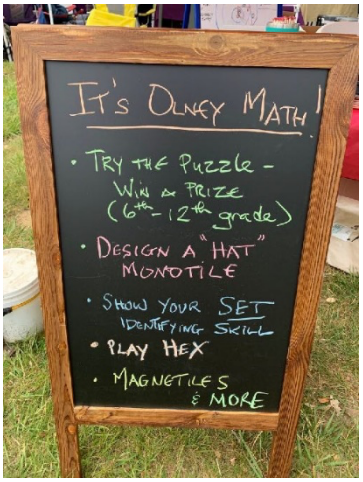
**What do you like most about mentoring undergraduate research projects?**
I find satisfaction in witnessing my students' intellectual growth while conducting research. I see them build valuable skills in reading relevant research, writing mathematics (including typesetting!), modifying existing mathematical models to create new ones, gaining a deeper appreciation of differential equations, and in general, strengthening their academic portfolios. As a bonus, I gain insights into how students think and how they learn. I then use this insight to enhance my teaching skills. I also find fulfillment in seeing my students improve their skills on managing time, expectations, and resources. I am curious to see the impact I have on my students' academic and personal lives… I guess I will see my mathematics legacy through them in a few years.

# Math at the Farmers Market

By Gregory E. Coxson, Olney, Maryland

This summer, I have been running a Farmers Market ``Math Booth'' one Sunday each month at my local Farmers Market in Olney, Maryland. If this seems a strange place for Mathematics, well, frankly, I often share that view. Still, this Market Math adventure reminds me of when I once worked on the BIG SIGMAA newsletter; we would explore different niches in the world of Mathematics outside academia.

A Math booth at a Farmers Market has proven to be a gratifying adventure. leading to unexpected “math moments”. I have come to think of it as an example of “Public Math'', a category of math activities that involve exposing the general public to Mathematics.




Our local market was founded in 2007 by a former local news reporter named Janet Terry and a former GEICO agent named Bobby Espinoza. It is modeled after the
thriving and creative farmers market in Charleston, South Carolina. It has a summer market that runs from May to November, and also a winter market that covers the remainder of the year. There are typically 70 to 100 vendors during the summer, and about 40 vendors during the winter (unless it is approach absolute zero). Some vendors sell farm produce, while other sell crafts or jewelry. The market is always entertaining new ideas, and always looks for new ways to serve the community. Janet especially has always been supportive of the concept of helping to inspire local students (and others) to study and enjoy Mathematics.

Figure 1. Sandwich board advertising the day's activities, using suitably bright Hagoromo chalk.

I moved to Olney from New Jersey in 2005, with my wife and kids. When the market was founded two years later, my wife and I were pleased, because we had enjoyed the wonderful farmers market in Madison, Wisconsin, where we did our graduate studies. We were only occasional visitors until our teenage son Michael started working as a manager at the market. For the first year or so, he could not drive to the market, so I would drive him, and would often stay on to help out.

Eventually, I began thinking of how I could bring Mathematics to the market. The gestation period has been long. About three years ago, I began wading in, by creating monthly mathematical puzzles for the market e-newsletter. The puzzles range from logic puzzles, to Eulerian path puzzles, to “making change” problems, and others. The puzzle challenge was limited to middle and high school students. The first student to solve the puzzle would win a $25 prize (this year it was raised to $35).

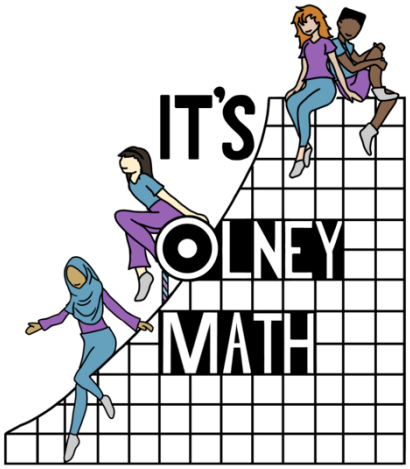
The contest aspect of the puzzle creates limits to the types of puzzles. They cannot have a small number of possible answers, and in particular cannot be “yes” or “no”. Problems that require a proof or essay answer also do not work in this framework. This has been one of the learning experiences at the market.

The biggest challenge with the monthly puzzle has been to settle on the right level of difficulty. The number of submissions has, frankly, been low. For the first year, there were only two winners; the second year, only one.

When Janet suggested doing an actual booth at the market, it took me a while to agree to it. When I finally decided, earlier this year, to commit to a booth, I insisted on doing it only one Sunday a month, and only during the Summer market (May to November). The central feature is the monthly puzzle. One of the most unexpected payoffs -- there has been a winner for the monthly puzzle every month so far.

**Selecting a Name**

Every market booth needs a name. Before "going into business", I had to get this done before all else. Market organizers loved ``Mathemagical'', a name I floated early on, but then decided against. Ultimately, I settled on "It's Olney Math". I like it because it gets at the idea that Mathematics need not be scary. It also describes what the booth is about - encouraging Math in our town of Olney.




Next, I needed a logo and a banner to hang from my tent. Here is where the market has proven to be a wonderful resource and community to work with. That is, there are artists and crafters at the market willing to offer their help, almost always for free. A local artist named Tim Francis, who works in construction, designed the first logo for me, which shows Sisyphus pushing a boulder (using the "O" in Olney) up an exponential curve. Janet thought it made Math look like a struggle. So, one of our teen helpers with artistic talent reworked the logo, keeping Tim's graph, but showing several young people playing on Tim's exponential curve.

Figure 2. The It's Olney Math logo. It builds on an initial design by Tim, an artist at the Market. The final version is due to one of the market helpers, Kai Larsen.

**Month One -- May 2023**

On the fourth Sunday of May, it was game on. Janet arranged for a tent, table and chairs. In addition, she waived fee usually charged for money-making enterprises, at least for this first year.

I brought activities and games for a variety of ages. I brought several games, including Rubik's Cube and a hand-made Hex board. I brought a white board for posting the monthly puzzle and a sandwich board for announcing the offerings of the day. I also brought with me a box of promotional material provided by a tutoring service in town, he was only one of the three I contacted that offered to support the booth.

I also prepped to do two mathematical card tricks, one of them a nice trick (by Professor Arthur Benjamin, who is a self-styled "mathemagician") using 20 cards from a standard deck. The other was a 4-card trick described by Persi Diaconis and the late Ron Graham in their book *Magical Mathematics*. Both are based on DeBruijn sequences, whose rich structure can be exploited to produce predictable outcomes robust to, say, the way, or number of times, you cut the deck. I don't typically do card tricks, so I had to practice the sequences of moves, over and over, until it was natural. My investment in learning the tricks paid off, because I had several customers who responded well to the question "want to see a mathematical card trick?" I was especially encouraged when I got questions afterward. One pleased customer actually did ask, "does it matter how many times you cut the deck?"

The star of this first market Sunday was the aperiodic monotile. This recent mathematical discovery has lowered the number of shapes needed to tile the plane aperiodically, to one, from Sir Roger Penrose's two, the “kite” and the “dart”. The search for the monotile, or known as “the Einstein”, has now yielded the now-famous “hat”, just this Spring, as I was getting ready to do the Booth. By the way, the term “Einstein” comes from the German for “one stone” and not from the name of a certain physicist.

Weeks before my first booth Sunday, I encountered a future market vendor named Tom Bentz who was learning to use a laser cutter, to make items for sale at the market. When I mentioned that I needed an aperiodic monotile, he offered to help. A day or so before day one, he delivered to me a box of laser-cut monotiles in two sizes.

I placed Tom's monotiles on the booth table along with other fun or intriguing offerings.
All day, the tiles attracted both children and adults, drawn to the challenge of fitting the entire set together without any gaps. The children needed no explanation of the tiles; they just found it fun. Some adults were interested, leading to deeper discussions of mathematical advances.
Figure 3. A brother and sister aperiodically tiling the plane (image created with help from BFunky.com).

Another popular feature was the set of Magnetiles that I borrowed from the preschool where my wife works. The idea was to cover the younger set. And cover that set it did, as I had two children playing with them next to the booth. One was Phoebe, the 18-month-old daughter of Cristin and Brandon Cooper, who run a booth selling soups, named Coop's Soups. I now make sure to bring Magnetiles each month, with Phoebe in mind.

It was especially encouraging for me to meet such a rich variety of people willing to try out this booth. This included a former puzzle designer from Israel, a gifted first-grader with a knack for tiling my table aperiodically, a group of hearing-impaired problem solvers who were drawn to my Rubiks cube, and a family with three children who spent the better part of an hour coloring paper copies of the hat monotile, to add to a joint tiling of a large piece of poster board.

**Month Two -- June 2023**
The Math Booth has potential along the lines of “if you build it, they will come”. What I mean is that the booth can be a venue for local (or perhaps not so local) mathematicians to visit and share their love of Mathematics. For the month of June, I was fortunate to line up a local artist named Lauren Kingsland, who makes quilts based on Indian Kolam designs.

Kolam is a practice mainly in the south of India, in which women draw patterns in the sand in front of their front stoops every morning. These can be very intricate patterns enhanced with color and added pebbles, often with one or more symmetries. I am told that the designs are different each morning, which is something incredible to imagine.

Kingsland agreed to clear her Sunday church attendance so that she could join me at the booth, and to bring along some of her Kolam quilts. I promised she could offer her quilts for sale. She showed up with not just a number of quilts, but with laminated sheets of paper, each one explaining a different symmetry one can find in her designs. This was a lot of fun, because the inside and outside of the booth were appealing to look at, and also because it was easy to quiz the children and adults who strayed into the tent about Mathematics and symmetries. Kingsland was able to sell several quilts. She said she appreciated the invite so much that she offered me a quilt for free (but not one of the Kolam quilts, which she was selling for several hundred dollars each).

Figure 4. One of Kingsland's Kolam quilts hanging in the tent.

For those few who found little interest in symmetries, I still had the aperiodic monotiles, popular as ever. For the teen helpers assigned by Janet to my booth for the day, I had the Ramsey-Theory-based card game SET. I explained to them what SET was all about, and they enjoyed trying to find sets (I got some practice as well). I recommend SET to anyone thinking of doing a Math booth; it is a great activity for quiet moments.

**Month Three -- August 2023**

I had to cancel the July date because of a vacation trip that came up unexpectedly. This gave me two months to create an August Math puzzle and to think of new activities.

One idea I decided to try for August was having one of the speed-cubers among the teen Market helpers show visitors how to solve Rubik's Cube. But this turned out to be a non-starter. Reasons range from the need to learn long sequences of moves, to the fact that many kids can already solve Rubik's Cube. Still, I have found it useful to keep a Rubik's Cube on the table in the tent. It tends to attract market-goers who love puzzles. Also, the teen helpers like to borrow it from time to time, during down times.

Better than Rubik's was to quiz visiting students on divisibility rules for prime factors 3, 9, 7, 11 and 13. Most visitors knew, or would strain to remember (with cues), the divisibility rule for 3. Then, the easy step to 9, followed by the somewhat different rule for 11; if we got this far, then to 7, and lastly to 13, an option for those that showed more stamina. I prepared big flash cards for each of these prime numbers, with lists of local zip codes. Each list was used to quiz a different one of the primes. So, I would pose a question like "which of these zip codes is divisible by 7?". I was wise to put the winning zip codes on the back ahead of time, so I could tell them (without flipping the flash cards) if they were on the right track. I was not sure this idea would fly, but it worked pretty well for middle and high school level visitors.

The Math Puzzle for today was pretty challenging. Solvers needed to take a 4x4 array of small-ish integers and re-arrange them so that every neighboring pairs, whether horizontal or vertical, sum to a prime. I got the idea from a book of vintage mathematical puzzles. The version in Wells is 5x5; I felt this was too hard, so I reduced it to 4x4. I gave a hint that most primes are odd. While this made the puzzle more doable, nobody solved it until almost end of market time. The winners were a young couple, Zach and Lindsay, who were so excited to have the first solution. Although they were college graduates, we decided to make an exception to the age requirement and award them the cash prize of $35.

**Month Four -- September 2023**

Whether during the summer or winter, a Market booth can expect to experience some weather. The September 24 date for the Math Booth coincided with a tropical storm passing the Mid-Atlantic region. I arrived to set up the booth in drenching rain. This soaked the cardboard boxes I use to carry my activity materials, and it made it quite hard to draw on whiteboard with markers. It even made it a challenge to write on my sandwich board using my prized Hagoromo chalk which I can typically count on to brighten things up. Any jostle of the tent triggered a waterfall that would splash and leave water spots on everything. The weather also put a damper on the number of visitors. Still, it was a good day and the four hours passed quickly.

One not-unexpected issue with the Math Booth is that visitors find the Booth confusing. What is this for? Do you run a summer camp? I often hear a hopeful ring in parents' voices when they ask this. Is this a business? No, I say, this is one of many Market activities to reach out to the community. In our case, it is meant to show a side of Mathematics beyond equations and "solving for x". After all, I add, our area serves such organization as the FDA, NIH, NIST, and the NSA, so there are many mathematically gifted parents, and their kids, in Olney and the surrounding community. That argument seems to be enough. What I find gratifying is that this conversation often ends with "I am glad you are doing this". On this day, I even had an industrial engineer named Andrew drop a fiver in the till for the puzzle award, just to support the Math Booth.


Figure 5. The tent on September 24, after the rains let up.

I came this day with a Tesselations exercise. I prepared several templates (from Robert Fathauer's *Tesselations* book which is aimed at such tesselation activities) that kids could color or create with. I was ready to take their designs and create 2D tilings with them. But this day I did not get the right ages (say, 4th to 6$^{th}$ grade) to try this activity. However, the great thing about a monthly booth is that I can keep my materials handy for future booths.

I also brought large sheets of construction paper to thrill folks with some Moebius strip cuttings. If you want to do such an activity, I had heard that it is best to cut strips in a 20-to-1 length-width ratio, so I came with plus-size construction paper. I also had to remind myself to bring scissors and tape. I had a set of four Moebius exercises ready, but it proved enough just to form Moebius strips (while visitors watched) and then cut them in two ways -- (1) right down the middle and (2) one third of the way from the edge. For the younger kids, the first is intriguing, and the second yields a surprise. That was the response of most of the visitors this day, but then there was 4-year-old Asher. He came to the booth with his parents and an uncle and aunt. Asher told me correctly, ahead of time, what the results would be. That gave me the wonderful opportunity to tell him, and his family members, that he was a pretty smart kid.


The Math Puzzle for September was a geometry puzzle whose solution relied on properties of similar triangles. I felt this was maybe too easy and I expected the teen helpers to get it with little effort. This was not what transpired, as it turned out; at end of day, they were all still offering wild guesses. The father of one of the teen helpers stopped by to tell me his answer of 64, along with a page of work done during the four hours of the market. His body language told me he was ready to celebrate. I had to disappoint him (the solution was 200). We discussed his approach, and concluded that he had made a simplifying assumption that doomed his solution. When I got home, the winning entry was in my email in-box. A 17-year-old named Jazmin had the answer. She said her approach was based on properties of triangles that are somehow the "same", but she could not recall the proper term for this same-ness. I wrote back to remind her of the mathematical property of similarity, and what it means for triangles to be similar.

Figure 6. Market helpers Isira (a speed cuber), Ethan (solved the May puzzle) and Kai (logo designer).

**Thoughts as the Season's Close Nears**

There remains one more Math Booth for the summer season -- October. While the Booth takes a lot of work, time, and a bit of investment, I have come to see it as a success, in some ways. However, my definition of success has had to evolve. Any success has less to do with the number of visitors, than on the effect it has on those one or two or three who come by and see even just one new thing that tells them to give Mathematics another look.

I am thankful that I have gotten to meet really smart kids and adults in my community. I am humbled by the help I have gotten from a small, but priceless community of mathematical friends, artists, and crafts people, as well as the incredible support I have gotten from Janet and other Market organizers. When it is time, I will be ready to store my sandwich board away, and to draw the curtain on this year's Math Booth. Will I want to do it again next year? What do you think?

## Message from the chair (continued)

I encourage you to check out each group's site (URLs provided below), if you have not already, and reach out to make the most of what they offer. This newsletter also includes a joint statement the three groups have put together to raise awareness of their existence and goals.

It has been my honor and privilege to serve in BIG SIGMAA as Secretary/Treasurer for two terms, and as Chair also for two terms. It is through the interest and dedication of volunteers that MAA's SIGMAAs continue to be active, so please consider being active and serving in BIG SIGMAA in any capacity, now or in the future.

As I step down from being an officer of BIG SIGMAA, I will be serving the MAA Southeastern Section for the next two years as chair. My dedication for the mission of BIG SIGMAA and interests in the field will continue, and I hope to be a more helpful resource to all of you and to members of the Southeastern Section.

Best of luck for this academic year.
Caroline Maher-Boulis
BIG SIGMAA Chair

To learn more about BIG SIGMAA, please visit http://sigmaa.maa.org/big/BIG_SIGMAA_Home.html

**BIG SIGMAA Officers**

- Caroline Maher-Boulis, Chair
- Namyong Lee, Vice Chair for Membership
- Jan Rychtar, Vice Chair for Services
- Vinodh Chellamuthu, Vice Chair for Programs
- Aaron B Luttman, Secretary/Treasurer

Interested in contributing to the newsletter? Contact Jan Rychtar at rychtarj@vcu.edu

# Joint statement from BIG Math Network, BIG SIGMAA and PIC Math

**BIG Math Network:**

BIG Math Network is a collaboration of AMS, ASA, INFORMS, MAA, and SIAM to promote careers in Business, Industry, and Government to students and faculty in mathematics, statistics, operations research, and data science. The Network is led by a Steering Committee composed of representatives from the five societies, industry, and academia.

BIG Math Network's goals are to:

- Communicate the value of mathematical science training in BIG to students, faculty, and employers.
- Facilitate connections between students, faculty, and BIG employers.
- Share knowledge about how to prepare for internships and BIG jobs.
- Curate and create best practices and training material that prepare students for BIG jobs.
- Collaborate with professional societies and BIG in connecting job opportunities with talent.

The principal vehicles for that promotion are career blogs at BIGMathNetwork.org and the Industry Connection webinar series. Anyone can subscribe on the website to receive updates from the Network.

**BIG SIGMAA:**

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.

This Special Interest Group of the MAA (SIGMAA) provides resources and a forum for mathematicians working in business, industry and government to

- Make professional connections
- Build partnerships
- Aid professional development
- Discuss important issues, and
- Help advance the mathematics profession.

The BIG SIGMAA plans and coordinates events at regional and national MAA meetings for mathematicians involved and interested in Business, Industry and Government. Events include receptions, panel discussions, paper sessions, poster sessions, speakers' lists and having BIG guest speakers. By becoming a member of the MAA and joining BIG SIGMAA you get access to the BIG SIGMAA community on MAA Connect. You can post questions, request resources, share experiences…etc with other BIG SIGMAA members.

Feel free to contact any of the officers of BIG SIGMAA for questions. For a list of the current officers, please visit our website at http://sigmaa.maa.org/big/BIG_SIGMAA_Home.html

**PIC Math:**

PIC Math (Preparation for Industrial Careers in Mathematical Sciences) prepares mathematics and statistics students for BIG careers by offering a semester course that engages them in solving a research problem from a BIG partner. The objectives of the PIC Math program are to: (a) increase awareness among mathematical sciences faculty and undergraduates about non-academic career options, (b)

provide students a research experience working on real-world problems from BIG, and (c) prepare students for industrial careers.

The main components of a year-long PIC Math program include

- a 3-day summer faculty training workshop,
- a spring semester course for students, and
- a student conference in the summer after participating in the PIC Math course.

The 3-day summer faculty training workshop helps faculty prepare to teach a PIC Math course with their own students at the own institution. It discusses what types of BIG problems students can work on, how to develop BIG contacts and get a problem from a BIG partner, how to mentor students who are working on BIG problems, how to run a spring semester PIC Math course, and how to help students learn the skills they need to work in BIG.

The spring semester course focuses on students solving an actual problem that comes from a BIG partner. The class is taught with very little (if any) lecturing from the faculty member. Instead the students are actively learning by working in groups of 3-4 students on a BIG problem and occasionally interacting with someone who works at the BIG partner who gave the problem. Students learn the needed content and skills as they work on solving the problem similar to how it is done in industry. By the end of the semester, students write a 12-page paper and create a 12-minute video describing their problem and their solution to it.

Communication skills are crucial for people working in industry. So, in the summer after the PIC Math course, students present their results at a national conference such as the MAA MathFest or SIAM national meeting.

From 2014 - 2021, the participants in PIC Math have included

- 154 universities and colleges
- 179 math/stat faculty members
- Over 2000 undergraduate students (41% female and 23% from underrepresented minority groups in STEM)
- Over 150 industrial partners have provided research problems and consultants for the students.