



AMERICAN SCIENCE



11

Tracing the Invisible Fabric
of Everyday Science: Field Notes

CONTENTS

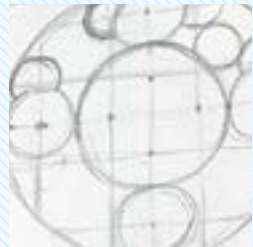
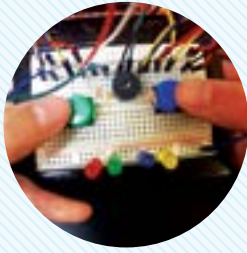
03

The TERC Scholars Program: Introducing Higher Education Students to Careers in Stem

Engaging Middle-schoolers with Meaningful Data—pg. 4

Play and Questioning as a Path to Lesson Plan Design—pg. 5

Inclusiveness Through Robotics: Designing Biomimetic Robots—pg. 6



07

Stem Learning While Making: All Lives Can't Matter Until Black Lives Matter

11

Tracing the Invisible Fabric of Everyday Science: Field Notes



14

Adult Numeracy: A Champion's Legacy



Letter from the President

TERC's commitment to and passion for social justice in education resonates throughout our new issue of Hands On!

Last fall the TERC Scholar's Program, an internship program led by Dr. Mia Ong, received its first cohort of interns, currently enrolled at Wheelock College. We hear directly from these young learners as they share about their immersion in STEM research and experimentation alongside TERC project teams, and how their futures could be impacted by gaining this unique lens on the power of STEM education.

Eli Tucker-Raymond and his research team share a story that demonstrates the power of making practices to connect students with STEM literacy through personally meaningful work. We meet Nasir, whose interest in clockworks and gears is supported in a safe and welcoming making space where he persists in a project, aided by his interest in social justice and his deep connection to the Black Lives Matter movement. Nasir's making culminates in a visual representation of the interconnectivity of a complex social justice issue.

Making science accessible and meaningful to the public is vital for policy discussions and political engagement in a democratic society. Yet today, public understanding of and attitudes toward science are fragmented and contentious. Research Scientist Brian Drayton shares his emerging explorations of how science knowledge is agreed on in communities, with a series of interviews about working people's lives and the sometimes hidden role that science plays.

We highlight the work of Mary Jane Schmitt, an unwavering and tireless champion for adult numeracy. All adults deserve the chance to enhance their numeracy skills and improve their sense of agency and chance at success in life's pursuits. Mary Jane's passion for empowering adults culminated in TERC's Adult Numeracy Center, which works with adult education centers, community colleges, retention centers, and prisons.

As you read through these articles, I hope the impact we can have as a community of educators to make STEM accessible and meaningful to all students becomes clear.

Enjoy the issue.

Laurie

Laurie Brennan, *President*

Editors: Valerie Martin, Jenni Haley and Zoe Keller

Administrative Support: Katie Stokinger

Design: One Visual Mind



The TERC Scholars Program: Introducing Higher Education Students to Careers in

STEM

Education Research by Maria (Mia) Ong



In September 2017, the Diversity, Equity and Inclusion Office at TERC established the TERC Scholars Program (TSP) with the goal of exposing college students, particularly those from underserved communities, to careers in STEM education research. TSP is a paid internship program in which students join an ongoing research project at TERC.

On site for up to 10 hours per week, each TERC Scholar becomes an active member of the project team and works under the supervision of the project's leaders.

TERC Scholars help to advance project goals and gain STEM education knowledge by engaging in authentic research activities, such as classroom data collection, literature syntheses, instrument testing, data coding and analysis, or case study development. Scholars come from a variety of backgrounds and majors (humanities as well as STEM) and bring their own interests and perspectives to these inquiries, as they gain work experience and reflect on potential career trajectories.

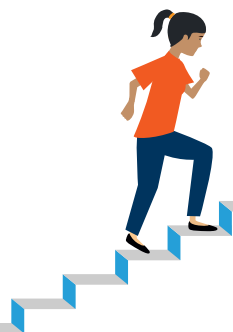
Students are assigned a mentor who assists them in navigating a professional workplace and are offered multiple professional development opportunities by TERC staff. These can include attending research seminars by TERC scientists, being advised on graduate school options, and having opportunities to give research presentations. Students participating in TSP may concurrently receive independent course credit at their colleges.

Since Fall 2017, in partnership with Wheelock College and working closely with Wheelock's Interim Dean of Arts and Sciences, Dr. Detris Adelabu, TSP has hosted Yingying Zhou, Lisa Liang, and Simone Ngongi-Lukula as TERC Scholars. Each scholar has written an article reflecting on the nature of her project work and the impact that participation in TSP is having on her professional goals.

The three projects that the scholars describe are supported by grants from the National Science Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Maria (Mia) Ong, Ph.D., is a Senior Research Scientist and the Interim Director of the Diversity, Equity and Inclusion Office at TERC. She serves as the Director of the TERC Scholars Program.

STEM Education Research



ENGAGING MIDDLE SCHOOLERS WITH MEANINGFUL DATA

by Yingying Zhou

I am a senior at Wheelock College, where I have majored in Mathematics for Teaching with a minor in education. At TERC, I work with Andee Rubin and her team on the *Data Clubs for Middle School Youth* project (NSF #1742255). This research project helps students develop their interest in mathematics and science and focuses on integrating computer science and math through data science. I am working with my team to test and revise several modules that introduce middle school students to the basic ideas of data science.

One such module is about pets, which we believe will be interesting to middle school kids. The students will collect their own data (about e.g., pets, social media, illnesses) using outside sources or large datasets from websites and then present their findings to their community. The pets module needed an initial dataset to get students started. This meant designing a questionnaire and conducting interviews.

Crafting the right questions

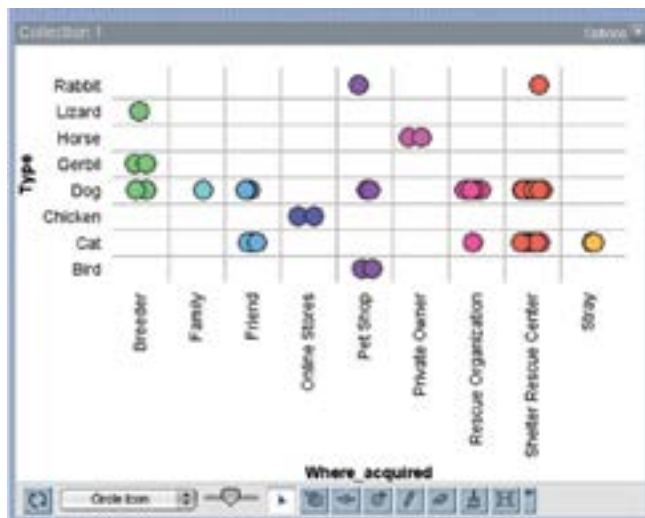
I quickly learned that it is difficult to create questions that yield good data. In my math or statistics classes, I'm usually given pre-determined questions to answer, and then enter the data, or all the data are handed to me to analyze. On the Data Clubs project, I went through a process of determining the kinds of questions I could ask that would result in quantitative data to collect.

TERC staff supported me with this process and helped me test my questions to find the right ones. I thought of creating questions about a pet's weight or how much money people spend on their pet. After testing questions with TERC staff, however, I realized the middle school students collecting data from one another might need different types of questions. They might not know the weight of their pets or how much money their family spends on pet care. Instead I designed a questionnaire about where animal owners got their pets—a question that kids this age might be able to answer more easily.

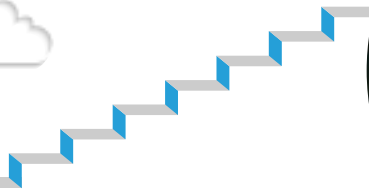
Building lessons to engage students

Next, I implemented and revised the questionnaire by talking to 50 TERC staff members. This helped me learn how to prepare for and interview people for research. Then, I entered the data into TinkerPlots, a data visualization and modeling tool designed for middle school students, and conducted an analysis of the data. The resulting graph (see Figure 1), shows that most of the TERC staff's pets are from shelter rescue centers. The data I compiled and analyzed will now serve as the starter dataset for the pets module.

The most important thing I have learned in the TERC Scholars Program is how to find topics that students are interested in and to create lessons around those topics, in order to encourage students to discover their passion for STEM. As I develop my teaching career, I will use this knowledge as I create lesson plans for my students.



Initial dataset for pets module shows that most TERC staff got their pets from shelters.



PLAY AND QUESTIONING AS A PATH TO LESSON PLAN DESIGN

by Lisa Liang

As a junior and first-generation college student at Wheelock College with a double major in Visual Arts and Elementary Education, I have been with Eli Tucker-Raymond's team on two projects that are centered around making. *Investigating STEM Literacies in Makerspaces (STEMLiMs, NSF #1422532)* looks at how people in makerspaces use representations in their work. *Integrating Computational Making Practices in STEM Teaching (NSF #1742091)* supports 6th to 12th grade teachers with computational making practices in their physics, biology, and mathematics classrooms.

When I graduate from Wheelock, I plan on becoming an elementary school teacher or an arts teacher. I work in the making lab at my campus, and I'm interested in how making can be integrated into classroom learning. With Eli's team I had the opportunity to explore electronic circuit building and work out how to build an effective lesson plan.

Getting confident with circuits

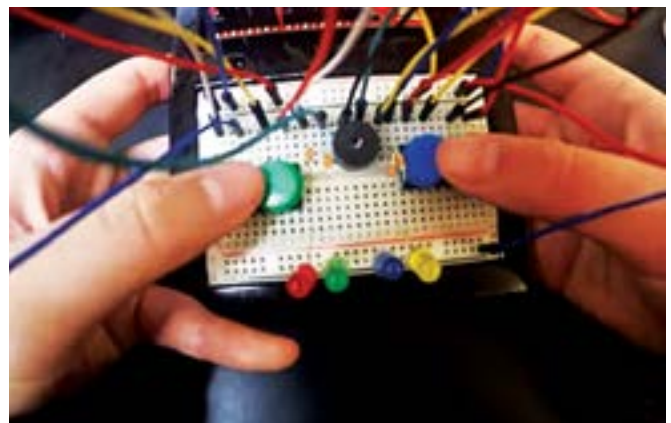
I was assigned to help our team test the usefulness of the Arduino for teachers. The Arduino is an open-sourced hardware development platform for building electronics projects; its physical programmable circuit board makes it great for beginners. When Eli first told me that I would be working with the Arduino, I felt intimidated. I had never explored circuits or understood how they worked. Despite my nervousness, I tackled the Arduino and found myself loving it.

At first, I followed the directions for building projects in the instruction booklet, like how to make a blinking LED light. Then I went on to modify the circuit codes to get different results, such as changing the order of the blinking lights. I kept a journal on what I was doing and questions I had, which let me track my thought process while putting the circuits together. I documented problems, researched questions online, and recorded how I tackled and debugged my designs.

Questions and play are science skills

Developing my own skills with the circuits and working through my questions led me to create a lesson plan on the circulatory system for fourth graders using the Arduino. Modifying the code makes the LED light blink like a heartbeat. A buzzer could be substituted to create a heartbeat buzz for those who are auditory learners. The lesson plan covers several days of a life science class and incorporates plenty of opportunity for students to play with the materials and ask questions.

My work at TERC has helped me to rethink how I feel about science and teaching in general. I grew up being "taught to the test," but that is not an effective way to teach especially with science. Teachers need to gain science skills and practices, especially the practice of asking good questions, to have effective science lessons. Students need to play with their materials, instead of always being taught from textbooks. Going forward, I look forward to passing on the skills and practices I have gained at TERC to my future students.

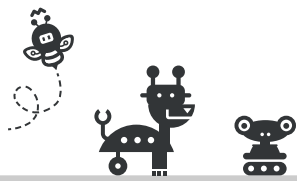


Lisa playing Simon Says with the Arduino



FEATURE // CONTINUED

STEM Education Research



INCLUSIVENESS THROUGH ROBOTICS: DESIGNING BIOMIMETIC ROBOTS

by Simone Ngongi-Lukula

I joined the TERC Scholars program as a senior at Wheelock College with a double major in Political Science and Global Studies. I have been working closely with Gillian Puttick and Debra Bernstein on *Designing Biomimetic Robots* (NSF #1742127), a project that aims to introduce middle school students (grades 6-8) and teachers to biomimetic design in a classroom setting. Biomimetics, also referred to as biomimicry, uses inspiration from nature to create new technological designs. Our team is designing and studying a four-week long curriculum that encompasses biology, robotics, engineering design, and computer programming.

The goal of this project is to have students from various academic backgrounds engaged in conducting hands-on design practices. Executing this project in the classroom will give us a better idea of the different approaches that students take when faced with design challenges. In addition, studying other robotics curricula will help us do a better job of developing our own curriculum.

Researching robotics potential

As part of my research role on the team, I set out to identify and locate other existing robotics curricula, by looking into a series of research studies done by various scholars and educators. This investigating helped me better understand the kinds of research that have already been done and possible areas of future research. I was amazed by the range of research that has been done at various academic levels. The field of robotics is constantly transforming.

The study that I found most interesting was done by Bradley Barker and John Ansonge of the University of Nebraska. It focused on the increase in achievement scores of youth ages 9-11, after a robotics curriculum was implemented in their afterschool program (Barker & Ansonge, 2007). Reviewing this study made me extremely eager to begin the design phase

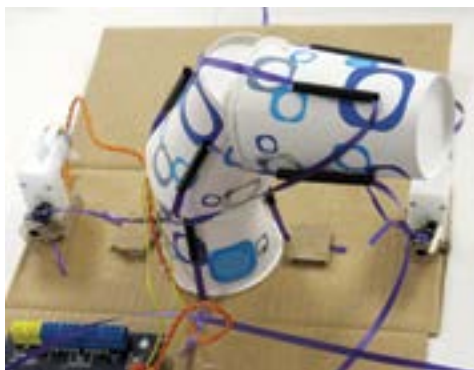
of the *Designing Biomimetic Robots* project. I was ready to see the influence that robotics, through engineering design and computer programming, would have on middle school students.

Inspiration for a new career path

Prior to interning at TERC, I had no idea that something like biomimicry existed. What made this project intriguing to me was TERC's guiding mission of making STEM—including exciting concepts like biomimicry, and professional fields full of potential like robotics—equally accessible to all. It is my hope that projects like this one continue to develop in schools to show our youth the range of opportunities that is available to them.

Working on this project has been tremendously inspiring, and after much reflection, I have decided to pursue a career in Urban Education Policy. TERC's mission to create equal access to STEM education for all students has motivated me to be a part of the change that I wish to see in the formal education system.

REFERENCES Barker, B. S., & Ansonge, J. (2007). Robotics as means to increase achievement scores in an informal learning environment. *Journal of Research on Technology in Education*, 39(3), 229-243.



A robot mimicking the structure of an elephant's trunk

STEM LEARNING WHILE MAKING:

All Lives Can't Matter Until Black Lives Matter

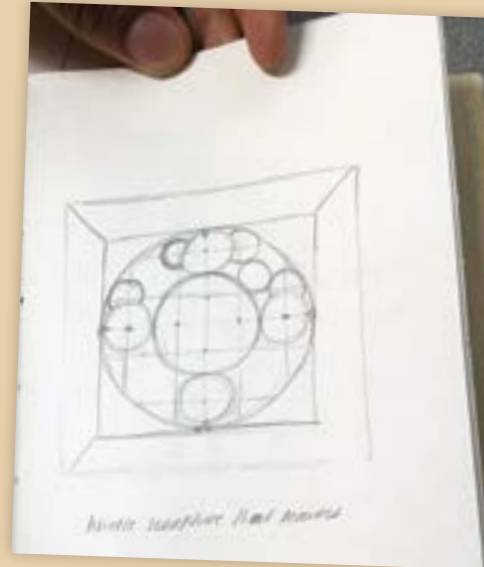


Figure 1: Sketch of Nasir's kinetic sculpture

This is a story about learning STEM content and practices while making objects. It is also a story about how that learning is contextualized in one young man's disruption of racism simply by trying to learn how gears work. Our project, Investigating STEM Literacies in MakerSpaces (STEMLiMS), focuses on how adults and youth use representations to accomplish tasks in STEM disciplines in formal and informal making spaces (Tucker-Raymond, Gravel, Kohberger, & Browne, 2017). Making is an interdisciplinary endeavor that may involve mechanical and electrical engineering, digital literacies and programming, mathematics and any number of science disciplines depending on the topic of what one is making. At the same time, makers pay attention to aesthetics—the look, feel, and artistic dimensions of their projects—and to the messages or ideas they want to express. Messages in making are important, because they reflect what makers experience and care about.



STEM LEARNING WHILE MAKING

All Lives Can't Matter
Until Black Lives Matter

Tapping into the idea that learning should be personally motivating, organizations including community centers and museums are focusing on encouraging youth to make things they care about with their own hands. Educators in formal settings like schools are excited about making as a modality for learning. When our team spends time in making spaces, we consistently observe the brilliance and tenacity of young people of color engaged in making. Yet people of color continue to be marginalized and underrepresented in STEM and in the new, digitally-connected maker movement (Vossoughi, Hooper, & Escudé, 2016).

Nasir and Black Lives Matter

Here, we focus on the case of one African American teenager, Nasir (pseudonym), to show how he used multiple literacies in a personally meaningful project to raise social-consciousness, and how that process contributed to his understanding and learning in STEM. We observed Nasir as he tried to build a kinetic sculpture that people would interact with to reflect on tensions between Black Lives Matter and “all lives matter” ideologies. Nasir’s example reminds us of the humanity of our youth not only as learners but also as people who participate in, travel across, and carry with them experiences in multiple social spaces. Nasir is learning engineering and STEM literacies through his lived experience as a young Black male.

We met Nasir at the South End Technology Center (SETC) in Boston, MA. SETC is a well-established community center run in the spirit and history of community organizing in Boston communities of color. Among other facilities, SETC houses a fabrication laboratory (fab lab) that contains a band saw, two laser cutters, a vinyl cutter, 3D printers, a large computer-controlled router, and several tools and materials for tinkering and building with electronics.

Nasir had been a Lab Steward and Youth Teacher in the SETC fab lab for four years, teaching community members how to use the tools and working on his own projects. He had also recently participated in a program at SETC called *Beyond Ferguson: #makingliberation*, which was a direct response to the killing of unarmed African American youth Trayvon Martin and Michael Brown, by a community patrol and by police, respectively; the subsequent demonstrations in Ferguson, MO in response; and the rise of the Black Lives

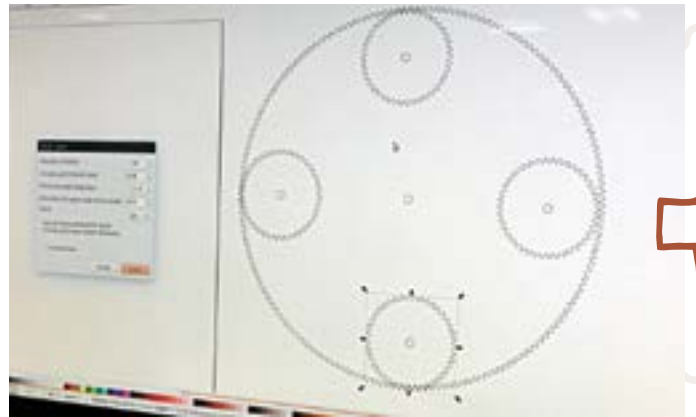


Figure 2: Beginning of planetary gears setup in Inkscape

Matter movement (Klimczak, Wallace, & Gaskins, 2016). In the program, youth gathered to talk about issues of racism, injustice, and liberation in their communities and to think about ways in which their participation in a community-oriented fab lab could address those issues. Nasir’s design was a closed set of planetary gears in which each smaller gear represented different marginalized ethnic/racial communities (see Figure 1). Nasir explained,

I wanted to show that all lives can't matter until Black lives matter or those that are feeling underrepresented matter. So I had this idea of [a] gear surrounded by four equal gears...basically they all revolve around that central gear to show that...you take out one gear and the project would stop working...And it won't work until you put it all back in.

Representations for Design

To move from concept to fabrication, Nasir worked through five kinds of representations: (sketches, mathematical equations and notations, vector-based drawings in the Inkscape software, physical prototypes, and professional engineering computer aided design (CAD) software). All the while, he employed his knowledge of digital fabrication, mechanical engineering, and mathematics.

First, Nasir sketched out his idea in his notebook, and while he did not include dimensions in his sketch, he did create proportional representations of the different gears (see Figure 1). He then laser cut a prototype that was made from circles, not gears, to approximate size. Nasir planned to laser cut his gears out of acrylic. He used Inkscape, a program that included a feature for making whole gear shapes and that would allow him to send files to the laser cutter.

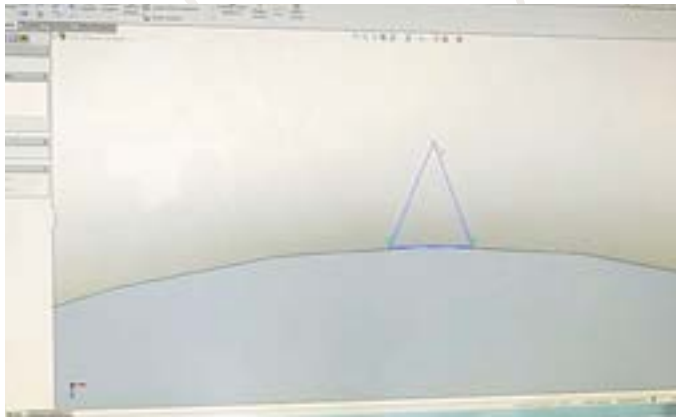


Figure 3: Triangle on circle shape in CAD program

To think both mathematically and aesthetically about the problem, Nasir relied heavily on the representations that were afforded to him through the software program. As he said,

I don't have the exact numbers, but I knew that this gear had to be bigger than these ones, but still smaller than the main one...I mostly just played around with it, I didn't know the exact numbers...I believe I divided it (pointing at largest gear)...by four...I just played around with like the number of teeth, the circular pitch of like say the radius of the circle ... Mostly it's the number of teeth ... and I was hoping that the number of teeth would match...then at some point I kind of gave up on just picking the right numbers and I just eyed it... And then I kept [it]...where there is little to no space between the [gears]. So it's like a locked system.

Nasir focused his attention first on the mathematical properties of gears, including the relationship between teeth, circular pitch, and radius (variables the software let him manipulate). He also used proportional reasoning to understand their relative size requirements. After trying mathematically to create the system, he “eyed” the images on the screen and created a system in which all of the gears fit within the outside chassis or “main” gear.

Troubleshooting with New Literacies

He then fabricated the gears on the laser cutter. When he put it all together the gears fit! But, when he went to turn them the gears were too close. That problem created too much friction, and two gears popped out. He decided that he needed to draw gears with a specific number of teeth at specified diameters so that the gear system would work. He needed to go back to the mathematics. To do so, he shifted from Inkscape to CAD software.

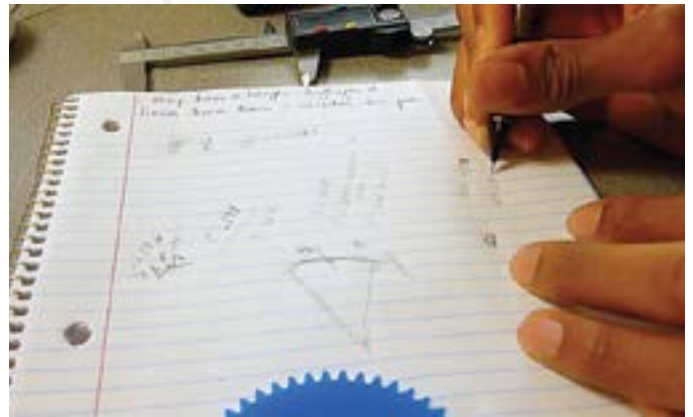


Figure 4: Sketch explaining the difference of movement between two gear shapes

“ Nasir focused his attention first on the mathematical properties of gears, including the relationship between teeth, circular pitch, and radius. ”

Nasir did not know how to use the CAD software. He had to learn to use it by requesting the help of a mentor and friend, who was an engineering student at a local college, and by looking up tutorials online. In addition to manipulating the new representational system of the CAD, Nasir was deploying STEM literacies of identifying the right tool for the job, communicating with others in his field, and learning to find information.

His foray into professional CAD modeling drew his attention to how gears were constructed. At first, he drew a circle and began creating triangles on top of the circle for the gear teeth. It looked similar to what he thought he had seen in Inkscape. But, the straight edges of the little triangles he was drawing for teeth were not flush with the rounded edge of the circle, nor were they one continuous shape (see Figure 3).

So, he and his friend searched YouTube for tutorials and found, that in the CAD program, gears were a series of thin wedge shapes emanating from the center of the circle that included a tooth at the end. The teeth were not triangles but were shaped like tall trapezoids with rounded tops. Nasir represented this difference, and their difference in movement, to us in a sketch (see Figure 4).

STEM LEARNING WHILE MAKING

All Lives Can't Matter
Until Black Lives Matter

Lessons Learned

Thus, Nasir's exploration of creating interactive art work about police brutality led to him learning about the geometries of gears and how they were designed. Through this inquiry, Nasir arrived at a place where he could begin to articulate the shape of gear teeth in relation to how they function—that there are gaps between them and curves in their shape, so that they can move more smoothly. His original issue, gears popping out, could now be resolved because of the attention and care he gave to the geometries of gears. He also succeeded because of the literacy practices he engaged—producing representations and moving across them at different times, identifying information, and communicating with others to solve problems.

Nasir's learning was supported through multiple channels. He cared about the message of his piece—all lives cannot matter unless Black lives matter. He cared about the aesthetics of his piece, how people would interact with the look, feel, and functionality of it. He was able to explore multiple systems of representation to select the best tool, and he had support from other people. Most importantly he was in a place, SETC, that created an environment that valued and supported his engagement.

We chose Nasir's work to illustrate STEM learning in making because African Americans and other marginalized groups are often blamed for their own underrepresentation in STEM, just as they are often blamed for being killed by police. Nasir's (still unfinished) project disrupted racism both through its content and through his authentic practice of investigating an object fundamental to engineering: gears. Through making he was able to deeply engage with STEM content and literacy practices. He willingly persisted throughout his project, because it was personally meaningful and socially relevant. If educators and other concerned stakeholders are to work toward equity across the lives of our students, then the brilliance, creativity, and ingenuity of African American youth and youth from other marginalized groups must be highlighted and supported. It is our job to create spaces for learning, like SETC, that prove to our children they matter.

“Nasir's exploration of creating interactive art work about police brutality led to him learning about the geometries of gears and how they were designed. Through this inquiry, Nasir arrived at a place where he could begin to articulate the shape of gear teeth in relation to how they function—that there are gaps between them and curves in their shape, so that they can move more smoothly.”

This material is based upon work supported by the National Science Foundation (#1422532). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

- Klimczak, S., Wallace, A., & Gaskins, N. (2016). Technologies of the heart: Beyond #BlackLivesMatter and toward #MakingLiberation. In Blikstein, P., Martinez, S. L., & Pang, H. A. (Eds.). (2016). *Meaningful Making: Projects and Inspirations for Fab Labs+ Makerspaces* (pp. 61-67). Torrance, CA: Constructing Modern Knowledge Press.
- Tucker-Raymond, E., Gravel, B., Kohberger, K., & Browne, K. (2017). Source code and a screwdriver: STEM literacy practices in fabricating activities among experienced makers. *Journal of Adolescent and Adult Literacy* 60(6), 617-627. <http://onlinelibrary.wiley.com/doi/10.1002/jaal.612/full>
- Vossoughi, S., Hooper, P. K., & Escudé, M. (2016). Making through the lens of culture and power: Toward transformative visions for educational equity. *Harvard Educational Review*, 86(2), 206-232.

TO LEARN MORE: <https://bit.ly/2FsHZTK>

FEATURE // BY BRIAN DRAYTON

Tracing the INVISIBLE FABRIC of Everyday Science

When it comes to science, policy documents and public attitude polling suggest a paradox: Americans think science is important and fascinating, but Americans don't know much science, and we are resistant or even hostile to science research in certain areas.

These are areas where the implementation of science-based policy is seen as having an ethical or moral component. The list is familiar —vaccination, climate change, GMOs, water quality, or chemical safety standards.

Public understanding and attitudes towards such topics are fragmented and contentious. As a result, the development and implementation of policies to protect health and wellbeing are hampered or prevented. Attempts to create consensus around such topics are challenged not only by a lack of science knowledge but by ignorance about how communities negotiate and assign values and meaning to science topics in their everyday lives.

So where and how are values relating to science negotiated? At the core, *conversation* is the mechanism and the setting that establishes and maintains community norms. Conversation creates the “common sense” of a community. In conversation we pass on information that supports our thinking or that rules out some alternatives. This information comes wrapped up with emotions, with attitudes and framing, and with implied or explicit valuation. Underlying these conversations is the nature of our community — who we talk with, how we are related, and how we influence one another.

The networks of relationship and conversation within a community can be thought of as an *invisible fabric*—one that holds, shapes, and expresses the content, value, and consequences of science, the meaning of science for its members. With an internal TERC grant, I am exploring how this invisible fabric functions within interest groups such as clubs, religious congregations, business associations, and local governmental bodies, and the roles they play in the creation of meaning about science that matters to them.

WHO DO THEY TALK WITH ABOUT SCIENCE?

In this exploratory phase, I've asked individuals to describe their group — who is part of it, how they meet each other, what activities they participate in. This then lays the groundwork for understanding their social network, and for learning how that group is in living exchange with others.

An organic farmer told me first about the other organic farmers that he talks with, but then, as he thought about it, he



Tracing the **INVISIBLE FABRIC** of Everyday Science



realized his circle was much wider and included conventional farmers, extension agents, and farmers at a distance who shared a common interest. For the manager of a nature reserve, his network includes colleagues, board members and advisors, and scientists and volunteers. The president of a regional garden club talks with other members, but also with horticultural professionals in the area, including sometimes university faculty.

Not surprisingly, each person belongs to many communities, and each participant has their own links outward to other talking groups. We are all embedded in a sea of science ideas and information—but our personal contacts often focus and stimulate our thinking and feeling.

SCIENCE BY ANOTHER NAME

When I ask, “What science is relevant to your group’s interests?” most interviewees have to think a bit before they can answer. As a science educator, I see topics such as new flower cultivars, the length and quality of the maple sugaring season, and the decline of shrimp fishing in the Gulf of Maine are obviously “science.” But from inside these interest groups, things look different — these aren’t necessarily labeled “science” in their minds at all. The garden club president told me about various speaker presentations at the club:



[A farmer came and] talked about conservancy, animal care ... field rotations. ... [A] speaker who judges flower shows [gave a] talk about invasive species—made us aware of what to pull up, the technique of

“We are all embedded in a sea of science ideas and information—but our personal contacts often focus and stimulate our thinking and feeling.”

leaving one area in your gardens wild, so wild organisms have a place to go. There was a talk about mason bees as important pollinators ... We are people who like to get our hands dirty ... We don’t usually do anything scientific ... Well, actually I guess we do, but it’s just not called that. Those things I just mentioned are scientific.

It’s no surprise that my interviewees “talk shop” with their peers about the details of their shared interests. Farmers talk about the weather, equipment, livestock, soils or crops; gardeners talk about soils, cultivars, pests, or bed design; hunters talk about the landscape, the movements of game, or stalking techniques. Everyone shares anecdotes and mishaps. A birdwatcher said:



... [B]asically if you’re in a particular place at a particular time, like Monhegan Island in May, everybody who puts on a pair of binoculars is “part of the community.”

CREDIBILITY FROM EXPERIENCE

In all of these exchanges, an important kind of evaluation is going on: who to listen to about what topics. As the organic farmer said,



Depending on how you feel about the person who is giving you the information, they have certain credibility ... in most cases, you give more credence to what those active farmers are experiencing and understanding about whatever it is, certain varieties of grass, certain land management practices, health issues with animals. Those [contacts] are very powerful.

DO CONTROVERSIAL OR EMERGENT SCIENCE TOPICS COME UP?

In the interviews, I listen to hear if any controversial or novel science subject has been the topic of debate within an interest group. If not, at the end I ask whether climate change

comes up, to learn more about how these groups negotiate values around controversial topics. In response, the garden club president gave a complex answer:



Climate change came up once. Politics comes into play with this. People tend to not take climate change seriously here, as opposed to the west coast.

I feel like that people don't get it, that that's what's happening ... [but] I don't talk unless someone asks. They are very sensitive to judgments about lifestyle choices. That's a real big factor for climate change, too.

I asked the nature center manager, "I'm curious how your group makes decisions relating to science. Do you ever have disagreements that need to be resolved?" He replied,



Sometimes. ... We're careful about if we approach somebody to do a lecture, if it's going to be something that's going to bring people in, it's going to be close to what's going on in the area. Like I said, the big focus [recently] was deer. The deer population is a big deal now down that way

... I'm really concerned about the whole climate change and melting-type thing ... I don't think people either are aware—one person thinks it's a hoax ... I don't know what it's going to take for people to finally realize that we need to do something about it. ... I think if things continue in the park, I think if the deforestation continues, I think we will do events where people actually can see what's going on with deer population, how it affects other animal populations. As things get worse in that regard, I think we will, because the forest will eventually just—the forest as they know it, will disappear.

When the issues are translated into the terms of current concerns, this enables people to engage with them but in terms of the values relating to their focal interest. The organic farmer translated "climate change" into "drought and deluges, the whole extreme events thing ... When you have stock, the big issue is water and grazing." The beekeeper said,



As a beekeeper, I have to pay attention to the flowers that the bees rely on. I probably have a hundred different species of plants, trees, and shrubs that

I keep track of, and there are years where there are tremendous changes, especially in the last few years. In 2009 or 2010, all the blooms were really, really early. More than two or three weeks earlier than usual, and I think it's a pattern that's repeating itself. It's not something that's really talked about much.

OBSERVATIONS SO FAR

These initial field notes support the idea that science topics do get evaluated within interest groups, but are not always seen as "science." Rather, they are seen as questions of art, craft, or professional practice, and evaluated in those terms. This relates to the hypothesis underlying this emerging line of work, that attitudes (and eventually actions) about controversial science topics are forged in conversation within communities of interest. In conversation, we can observe the processes by which "facts" are turned into consequential knowledge, evaluated in the light of community values, and given meaning by the process of negotiation in trusted settings.

Next this project will focus on three different communities of interest to identify and describe the social structures they use to create consequential science knowledge on a contentious science topic, and analyze the processes by which they make their own meaning about the science.

Looking ahead, we hope to design an experiment to test our understanding of these communities' ways of working, phrasing a science controversy in the language of their interests and concerns and tracing the paths by which meaning is made and integrated into the invisible fabric.



Adult Numeracy: A Champion's

The importance of adult literacy is well understood, but adult numeracy remains one of the most marginalized areas of education. The persistent need for adults to improve their math skills outpaces the funding and the academic support available.

Language barriers, economic hardships, and a history of interrupted school experiences can make returning to school a daunting prospect. Adults who seek out classes to improve their math skills demonstrate courage and deserve respect. Mary Jane Schmitt (1947-2015) was dedicated to the adults returning for a second chance at learning mathematics. The Adult Numeracy Center at TERC (ANC) was her brainchild; the culmination of her life's work supporting these adult learners.

Mary Jane joined TERC in 2000, excited to learn about reform math from the *Investigations in Number, Data and Space*® curriculum (TERC's K-5 inquiry-based hands-on math program), to find out about analyzing classroom discourse and collaborative research from TERC's Chèche Konnen Center, and to bring the work of Kliman, Mokros, Nemirovsky, Rubin, and Tierney on data and graphs to adult math learners. While at TERC, Mary Jane co-authored the *EMPower*™ series, led professional development in states across the country, wrote about the differences between mathematics and numeracy, made the case for teaching algebra to students who hadn't mastered their times tables, and contributed to international assessments of adults' numeracy.

Mary Jane was an inspiration to many adult educators. With characteristic energy, she recruited teachers to the Massachusetts adult education Math Team, helped publish



Legacy

their research stories, crafted a volunteer training component called VolUME (Volunteers for the Ultimate Math Experience), and more. She advocated tirelessly for including adults in K-12 math reform initiatives and worked with colleagues to have the Adult Numeracy Network (ANN) acknowledged as an affiliate of the National Council of Teachers of Mathematics.

EMPower has impact

Mary Jane's work on the *EMPower* series (along with co-authors Steinback, Donovan, Merson and Curry) was groundbreaking. The *EMPower* series offers over 100 investigations, bringing opportunities for mathematical reasoning and connections to adults who typically experienced math learning as the process of silently finding one right answer. The teacher books offer support for instructors who are new to math teaching. Well over a decade after it was first published, *EMPower* has fans all over the country. One admitted:

"At first, EMPower was not something I wanted to do but after the first TABE test, I saw all their scores went up. It didn't matter that I didn't want to do it, what mattered was that my students retained the information that they learned and were able to look at other problems and see patterns that would help them solve new problems."

—NY adult ed teacher

In response to the increased mathematical rigor of the College and Career Readiness Standards for Adult Education and the new high school equivalency tests, three of the *EMPower* titles were revised and released in 2015-16. The updated *EMPower Plus* titles—Everyday Number Sense, Using Benchmarks, and Split It Up—help students build a foundation of number and operation sense for algebraic thinking. Mary Jane was keen to revisit operations with whole numbers, fractions, and decimals. By examining sets of equations and articulating patterns, adults can more readily connect ideas across math content strands, find more efficient solution strategies, and justify their approaches.

EMPower Plus lessons give students an opportunity to examine statements like the ones below. They investigate whether they are true, both by generating their own examples or by referring to a set of equations or expressions that is provided and testing their generalizations. The goal is for students to revise their beliefs and refine their expectations about the effect of operations on pairs or groups of numbers.

Mary Jane found that adult thinking was like that of the schoolchildren that Russell, Bastable, and Schifter examined:

... Adults with limited operation sense tend to apply their understandings of operations with whole numbers to non-whole rational numbers. This leads to generalizations such as:

- *Multiplication makes things bigger.*
- *You cannot divide a small number by a larger number. So, dividing 5 by 39 can't be.*
- *You line up whole numbers in a right-justified column before adding and subtracting, so you must treat decimals the same way.*

Some ideas people have about operations on whole numbers hold up when working with decimals or fractions, but others do not.

In 2016-17, the Kentucky Adult Education (KYAE) Skills U, an organization that helps adult students attain high school equivalency diplomas and prepare for college and career success, conducted its own pilot test using the *EMPower Plus* titles. Anecdotal data show that *EMPower* lessons help students to reason using math. Instructors agreed that if students participated in even one lesson, they come away with a better foundational understanding of math.

*“With **EMPower**, students see math as related to their lives.” —Gayle Box, Senior Associate of KYAE Skills U*

Due to the success of the 2016-17 *EMPower* pilot, KYAE Skills U is working to expand the program as a professional development opportunity across the state.

The California Department of Corrections and Rehabilitation adopted *EMPower* for similar reasons. Now math instructors in minimum, medium, and maximum security facilities have instructional resources that promote strategic problem solving as well as examining alternate solution pathways.

Over the years, the ANC has grown beyond the development and support of *EMPower* and is now a hub of activity and resources for adult education math instructors, with the goal of helping adults and young adults understand how math is present and relevant in everyday life. ANC staff and consultants are active on the national stage. The ANC's current director, Donna Curry, edited the Adult Numeracy Network's newsletter for 12 years and mentored recent office-holders and recipients of the Network's practitioner research grants.



Figure 1: Mary Jane at a professional development workshop

Adult Numeracy: A Champion's *legacy*

SABES PD Center for Mathematics and Adult Numeracy Comes to TERC

Just four years ago in Massachusetts, the Adult and Community Learning Services division of the Department of Elementary and Secondary Education solicited proposals for centers that would be responsible for delivering professional development to its adult basic education workforce in content areas such as math, reading, and English language learning. Under the leadership of Donna Curry, TERC bid for and was selected as the new SABES PD Center for Mathematics and Adult Numeracy. In its first few years, the Center and its team of curriculum specialists have developed and run several new courses (including face-to-face, online and blended options), reaching teachers in all corners of the state. Among its successes, in 2016-2017, 362 instructors attended adult numeracy center offerings. An impressive number given that the number of full-time teachers whose jobs offer paid professional development hours is estimated to be about 320.

With no state university-based program offering courses on math instruction for adults, the Center aims to fill in as many gaps as possible. Among the 20 offerings provided in 2017, the ANC staff led *Analyzing Student Work to Inform Math Instruction*, the *Mathematizing ESOL* (English for Speakers of Other Languages) series, and *Exploring Exponents*.

In 2017, the ANC also received support from the Massachusetts Department of Elementary and Secondary Education to create a Curriculum for Accelerated Mathematics (CAM) that advances conceptual understanding with the purpose of easing the transition for learners enrolled in adult basic education to successful performance on tests for high school equivalency and credit-bearing college courses.


In launching this work, Curry and ANC staff have set out to answer three questions:

- 1 Does CAM help students move to a higher math level?
- 2 Does CAM help teachers (and students) think differently about what math is?
- 3 Does CAM help teachers teach more conceptually (and value doing so)?




Garden Fence Challenge
U1.L2

I have 100 feet of fencing.



I want to make a rectangular garden that has a fence all the way around it.

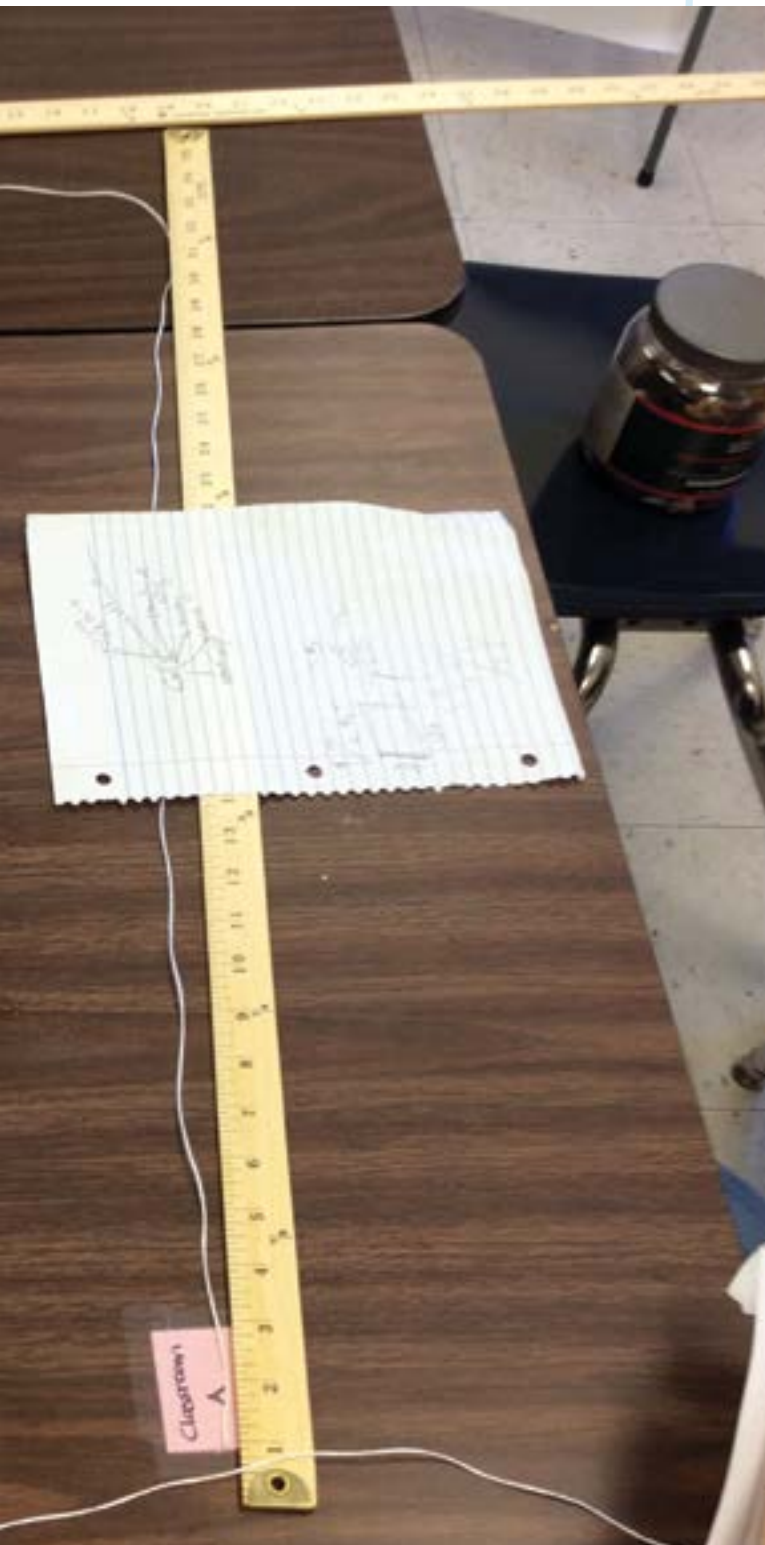


What size will the garden be?
Show how you know you will use all 100 feet of fencing.

Extra: How much space will I have in my garden?

© Adult Numeracy Center at TERC 1

Figure 2: Adult education students in South Boston, MA, solve the Garden Fence Challenge (a perimeter and area problem). They explain their reasoning for why 100 feet of fencing would be needed by using string and yardsticks to show the dimensions of the garden space.



The CAM units provide instructors with a variety of hands-on, real-world lessons and activities designed to demonstrate and reinforce the connections between math content areas. They begin to integrate algebraic thinking and proportional reasoning in Unit 1 which also illustrates the application of those ideas through geometry and data tasks.

Several units are built on *EMPower's* strong focus on conceptual understanding. These units differ from typical curricula in that multiple math concepts are taught at the same time with one essential topic anchoring the lessons. Concepts from algebra, geometry, number, and data are woven together. Each unit closes with a common workplace dilemma that requires students to demonstrate their ability to reason their way through problems and scenarios.

When Curry and her team observe pilot sites, they see that the math is far from easy, yet students seem to be welcoming the challenge. Mary Jane would be proud. She insisted that a first-rate education be accessible for everyone—teachers and students—particularly for those who didn't get a fair shot at math learning the first time around.

For more information:



EMPower Plus

extending mathematical power

EMPower.terc.edu

**Adult
Numeracy
Center**

adultnumeracy.terc.edu

@TERCAAdultNumrcy



PD Center for Mathematics
and Adult Numeracy

[sabes.org/pd-center/
math-and-numeracy](http://sabes.org/pd-center/math-and-numeracy)

@TERCAAdultNumrcy



Adult Numeracy Network

adultnumeracynetwork.org



JOIN US: MAY 14-21, 2018

We invite your participation in

The 2018 STEM for All Video Showcase

An interactive online event at:

<http://stemforall2018.videohall.com>

Save the dates and join the conversation.

On May 14th - 21st more than 200 projects, funded by NSF and other federal agencies, will share short videos of their work aimed at transforming the STEM educational landscape. If you are a researcher, teacher, administrator, funder, policy maker, or parent, you will want to view these videos, discuss them online, and vote for your favorites. Filter the videos by grade level, topic, intended audience, to find those of greatest interest to you.

The videos are brief (less than 3 minutes), yet they effectively portray current work to broaden participation in science, technology, engineering, mathematics and computer science. Collectively, the videos explore topics relevant to k-12 classrooms, undergraduate education, graduate education, as well as STEM experiences provided in informal settings.

Each video has its own discussion where you can share your ideas, thoughts, impressions and suggestions with others who have also viewed the video and with the presenter. The presenters are eager to hear feedback from multiple audiences who have diverse perspectives.

Ten videos will be selected at the end of the event to receive the Public Choice Award. Vote for the videos which you feel most effectively convey their innovative ideas through a visual medium. Under each video you will see links to vote through Facebook, Twitter or online ballot. Let your opinions be heard!

The video showcase platform, was developed by TERC, to promote the sharing of innovative STEM projects through video and discourse. It is a new way for practitioners and researchers to engage with each other and the public at large. TERC partners with six NSF funded resource centers: MSPnet, CADRE, CAISE, STELAR, Cyberlearning, and CS for All Teachers to maximize outreach and participation. This is the fourth year that we will be running the event. Last year's event continues to attract visitors and has had over 50,000 unique visitors from over 185 countries. The Video Showcase is funded by the National Science Foundation, award #1642187.

Be sure to save some time each day during the week of May 14th to view, discuss and vote!

INVESTIGATIONS

TRANSFORMING MATHEMATICS
TEACHING & LEARNING



The *Investigations Center for Curriculum and Professional Development* is dedicated to advancing the teaching and learning of mathematics for all students and teachers. The Center's website offers information and resources about the curriculum, designed by the authors of *Investigations*. investigations.terc.edu



A Curriculum that Makes Sense

Investigations 3 is a focused, coherent, and rigorous K-5 mathematics curriculum. Fully aligned to the content and practice standards of the Common Core State Standards (CCSS), deep and careful attention is paid to mathematics content and to student thinking and understanding. Making sense of mathematics is at the heart of the work, for students and teachers.

Connect with
the Authors
on the
INV3 Blog



Quote of the day ...

“ We can have a mathematical argument and still be friends at recess. ”
— Tweet by a Grade 1 teacher



Communicating
and sharing ideas is an
essential part of
professional learning.
Join us on Twitter.
[@INV3_Math](https://twitter.com/INV3_Math)



Investigations 3 Professional Development Improving the Teaching of Mathematics

Workshops & Institutes
Online • Customized
[investigations.terc.edu/
professionaldevelopment](http://investigations.terc.edu/professionaldevelopment)



Summer 2018 Offerings

WORKSHOPS AND INSTITUTES

Investigations 3
in the K-5 Classroom

Hanover, NH:
June 26 – 29, 2018

Bedford, MA:
July 24 – 27, 2018

Math Practices in
Investigations 3 Institute:
MPs 2, 4, 7, 8

Arlington, MA:
July 12 – 13, 2018

Arlington, MA:
July 25 – 26, 2018

Math Practices in
Investigations 3 Institute:
MPs 1, 3, 5, 6

Arlington, MA:
July 23 – 24, 2018

CONTACT US

to learn more about hosting
a workshop, or about bringing
Investigations PD to your
school or district.

Telephone: 617.873.9785

Email: investigations@terc.edu

ONLINE COURSES

Implementing *Investigations 3*
in the K-5 Classroom

June 20 – August 1, 2018

Supporting Math
Learning

June 20 – August 1, 2018



VideoReView

VideoReView is video-supported professional study in which teachers analyze video of their own science discussions and meet with colleagues to discuss students' ideas and reasoning

Notice ... Analyze ... Respond

- Use video technology to see patterns in students' learning you couldn't see before:
- Notice what your students are thinking
- Analyze where they are on their path toward the learning goal
- Respond more effectively in the moment or upon reflection

HOW DOES IT WORK?

Form a school team of three to four colleagues. Select class science discussions to videotape and study. Share video cases with your team. Use the learning sequence to guide your study.



PLAN a Science discussion



ENACT and video class discussions



STUDY the video using VRV software



MEET with your colleagues in Video Club meetings



THE RESEARCH

We are studying how *VideoReView* helps teachers to notice, analyze, and respond to students' science thinking.



OVERVIEW



METHODS



IMPACT

TO LEARN MORE VISIT: <https://inquiryproject.terc.edu/Videoreview> **OR CONTACT:** videoreview@terc.edu