

The impact of these workshops has been felt by all the participants. The post workshop survey responses have been overwhelmingly positive—100% of the respondents feel that the workshop was worth their time. This includes the group leaders as well as the junior participants. A few responses from the post workshop survey sampled here indicate the positive response: “My group was productive and enthusiastic the whole week and it was a great work environment. Doing math in an all-female group was a really positive experience and I left feeling super motivated.” Another participant said her favorite part of the workshop was “Establishing a new group of collaborators. I’ve honestly never developed this skill and I’m glad to have had this opportunity.” The workshop also provides a time to have in-depth conversations about work-life balance and issues of starting a family or two-body problems (i.e., job searching with a partner who is also an academic) as well as dealing with the promotion and tenure process. For many women participants, they were able to establish a research project despite being in a high-teaching-load institution, or post-pregnancy leave. The workshop has enabled participants to jump start stalled research programs and gain tenure and/or promotion when the prospects had previously seemed unlikely.

Many of our past participants have now returned as group leaders or organizers. As the community continues to grow and flourish, bringing new generations of women into the fold, we remain thankful to the mathematical, government, and industry institutes who facilitate the funding and logistics. It’s so fun to go to conferences and see that mini-symposia related to the WIMB work have been organized by workshop participants. I can catch up with past participants and hear about their ongoing successes and to see how the research projects have developed over the years. Personally, I gained a new sense of direction and excitement about my research portfolio and met many colleagues I know I can count on for career advice and encouragement. I’m lucky to have been able to participate in the first Women in Mathematical Biology workshop and feel equally privileged to continue organizing these workshops and to meet the up-and-coming researchers in my field.



Rebecca Segal

Credits

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Collaborating Across Disciplines

Benjamin Braun and Pooja Sidney

As a mathematician whose research is in geometric and algebraic combinatorics (Braun) and a psychologist who studies how children understand math concepts (Sidney), it might not be immediately clear how we benefit from collaborating. However, we have found many shared interests and goals in the realm of mathematics teaching and learning, and our collaboration has developed in positive and unexpected ways. Our goal in this article is to share some of the things we have learned about cultivating and maintaining a productive collaboration across disciplines and to explain why this has been valuable for each of us.

Collaboration has many forms. Many of us collaborate within our own disciplines. Perhaps someone else within our field has disciplinary expertise or access to tools that we do not. Often, these collaborations are transactional, enduring only to serve a given project and ending when that project is completed. Sometimes, collaborations have more depth, are more personal, and reflect relationships in which we continue to invest over time. Many of these long-term collaborations are focused on generating new questions and ideas or making connections between different fields. In this setting, our collaborators often become our friends and help drive our work forward in new and more interesting ways. In our experience, interdisciplinary collaboration can also take both transactional and relational forms, with relational collaboration both requiring more work and being ultimately more fruitful and gratifying. So, what does it take to build a relational, interdisciplinary collaboration? We have found that there are five key ingredients: build a network, identify shared interests and goals, work to understand each other’s disciplines, value multiple types of outcomes, and be patient.

Build a network. One of the critical ingredients in starting a good collaboration is (and yes we know this sounds lame but it is incredibly important) to invest time in building your network. If you don’t *know* people outside your discipline, then it is difficult to *make connections* with people outside your discipline! For example, we met because Ben had served on committees outside the math department with a senior psychology faculty member, Christia Spears Brown. When Pooja was hired, Christia told her to talk to Ben to make a connection with the math department. We

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met for coffee, found out that we have several common interests related to how students learn math, and this led to an invitation for Pooja to speak about her work in the Math Department Teaching and Learning Seminar. Note that this collaboration was the result of multiple actions: Ben agreed to serve the university beyond his department and made a point of engaging in those activities. Pooja sought out connections with others in a new place, and Christia made a point of mentoring Pooja as a new faculty by helping expand her network. Then, Pooja took Christia's advice and sent Ben the following email:

I am a new faculty member in the Psychology department, and my primary area of research is children's mathematical thinking and learning. Christia Brown suggested to me that you might be a good person to know here at UK! Do you have any interest in a brief meeting, perhaps over coffee, sometime in the next couple of weeks? I'd love to know more about your interests in mathematics teaching & learning and your work with pre-service teachers here.

I look forward to meeting you!

So this leads to a key ingredient of collaboration: quality collaborations do not happen on a whim, they require continuous engagement so that everyone is in the right place at the right time for a connection to form.

Identify shared interests. Once you have made a connection with someone, our view is that the best way to identify shared interests is to have conversations. While there are other ways, for example, checking out someone's professional webpage and looking at their identified areas of interest, recent projects, and current products, a static document never tells the whole story. In a conversation, you can get a better sense of your prospective collaborator's thought process. What problems do they seek to solve? What approaches do they take? What informs their thinking about potential solutions? Sometimes connections are immediately clear; in our case, we immediately identified that we were both interested in improving mathematics education for preservice teachers. Some connections are more distant, yet the potential for developing shared interests is there. An example of this for us is that we are both interested in the role of identity in mathematical learning, but the ways in which our interests overlap only became clear after many conversations across several years. What is important is to be attentive to potential connections, even if they are not immediately obvious; we have both had experiences with attempted collaboration where others were not actually committed to learning something new.

Not every conversation with a potential collaborator will necessarily result in future collaboration. If there are not common intellectual or professional interests or themes, then this might not be the best collaboration, at least at that

moment. Since all of our interests evolve over time, building a network means having the opportunity to revisit a possible connection later. Also, just as with any other relationship, sometimes a potential collaborator is not a good fit.

Work to understand each other's disciplines. One major challenge of identifying shared interests and engaging in intellectual conversation across disciplines is grappling with differences in disciplinary culture, history, and language. Unfortunately, it is common for faculty in different academic disciplines to be siloed in their respective departments and colleges. One consequence of this is that in our doctoral training, especially in mathematics, it is uncommon for students to take graduate courses outside our primary discipline. Another consequence is that faculty often need to put in effort to generate and maintain disciplinary knowledge outside their field.

This is already a challenge within disciplines, given the highly specialized nature of modern research. For example, there are typically many bridges that researchers in PDE, combinatorics, and machine learning must cross in order to develop a deep understanding of techniques and methods in the other fields. However, meaningful connections between these areas exist. Similarly, within psychology, there is often little discussion across experimental and clinical areas, despite clearly overlapping interests (for example, in addressing mathematics anxiety). Across disciplinary boundaries, the obstacles are even greater, especially when crossing between the humanities, social sciences, and physical/natural sciences. In many cases, methods, goals, professional standards, and even epistemological foundations are distinct and sometimes contradictory.

Because of this, interdisciplinary collaboration requires that everyone involved be genuinely curious to learn more about each other's fields, and be willing to put in substantial effort to learn new modes of thought and new models for what it means to know. What does this mean for us? For Ben, it means reading papers in psychology, learning more details about qualitative, quantitative, and mixed-methods studies, completing training in human subjects research required by our Institutional Review Board, and learning about survey design from Pooja. For Pooja, it means learning about advanced mathematics, goals and expectations for junior mathematicians, different formulations of success in mathematical work, aspects of the history of mathematics and math education, what mathematical teaching and learning look like in practice, and ongoing debates about all of these topics.

Value multiple types of outcomes. Given the amount of effort needed to build our interdisciplinary knowledge, a natural question to ask is: "what is the purpose of investing time to understand other disciplines?" In academia, our reward systems are set up to focus our energy on a narrow range of outcomes, including high-impact publications. While these are certainly possible outcomes from a collaboration, there are many other possible outcomes that are

equally valuable, even if they are not rewarded institutionally in the same way. Ironically, many of these valuable outcomes have a significant positive impact institutionally, professionally, and personally. In our own collaboration, we maintained open-ended goals focused on learning about each other's work instead of aiming to produce specific products. We acknowledged from the beginning that our collaborative efforts might end up producing traditional academic products (and this is turning out to be true), but this was not something that either of us required. Having this philosophy as a foundation for our work was a critical ingredient for us, and allowed us to be flexible in exploring all possible ways forward.

So, in addition to learning about shared interests, an initial conversation with someone can also include a discussion about how a potential collaboration might support your general intellectual and professional goals. Concrete goals might include designing a workshop, developing an intervention, conducting a research project, or writing a paper. More open-ended goals might include understanding another person's disciplinary perspective, identifying connections between disciplines, facilitating connections for our students, or maintaining an updated understanding of research developments in a related field.

For us, it was helpful to identify a specific intersection point. Initially, we focused our conversations on the topic of how math majors conceptualize arithmetic involving rational numbers. Since one of Pooja's research areas is on understanding how children learn division by fractions, and Ben has a lot of experience teaching math majors (including pre-service high school teachers), this turned out to set the stage for rich conversations. Following many conversations, we decided to design an experiment involving math majors and rational numbers conducted in Pooja's lab, and we started collecting data during the 2019–2020 academic year. Unfortunately, this project was halted by the COVID-19 pandemic. While reflecting on the partial data we had managed to collect, we realized that our study design was not going to achieve what we had wanted it to. Here, the open-ended nature of our goals allowed us to shift to new ideas. Moreover, for Ben, this was a valuable experience in learning how intellectual work in the social sciences progresses, with pilot studies informing later studies leading to published work. There have been many more outcomes from our collaboration (more on these below), but this is an example of how collaborative efforts often take time to fully develop and mature.

Be patient. One theme that has come up repeatedly so far is worth pointing out explicitly: collaboration across disciplines requires patience, as each of the other four ingredients to successful collaboration take time. Patience is required to build a network and allow that network to generate authentic connections. Once we have formed a connection, we shouldn't expect to identify all of our common interests in a first conversation. Sometimes there will be obstacles to

communication arising from differences in disciplinary culture or individuals' approaches to brainstorming and problem solving. In our collaboration, having patience has given us time to build trust and mutual respect and to cultivate our focus on cooperation, understanding, and curiosity rather than competition, judgment, and evaluation. Patience is the key ingredient needed to allow the process of building a relationship to unfold and develop and to support the other ingredients for successful collaboration.

Maintaining the collaboration. Once a collaboration is established with shared interests and goals, how do we keep it going? One effective approach is to build time for your collaboration into your normal routines. This can be done in ways ranging from as simple as scheduling a regular coffee break or walk to ambitious activities such as applying for a joint grant. For us, two things that have helped maintain our collaboration have been to develop research projects to work on, for example the project about math majors and rational numbers that we mentioned previously, and to broaden our shared network and welcome other people into our collaboration.

Collaboration is fundamentally about bringing together multiple perspectives and drawing on the diverse strengths of a collective. As our ideas expanded, our group did as well. In our first project, running from 2019–2020, we invited a mathematics graduate student (Julianne Vega) and a psychology undergraduate thesis student (Gabrielle Eismann) to share in its development and execution. While this project has not yet resulted in any published products, it did produce a draft of a survey to measure student self-evaluation of mathematical proficiency and some pilot data regarding that survey. During the pandemic and following the racial justice protests of 2020, we were part of a team of six co-organizers who started a University of Kentucky working group on Ethics, Equity, Inclusion, and Justice in the Mathematical Sciences (EEIJMS), and this group attracted faculty and graduate students from mathematics, psychology, STEM education, and engineering. The EEIJMS working group meets six times per semester, so this builds regular opportunities for conversation into our schedules which helps to maintain our collaboration. It has also increased the scope of our collaborative efforts; for example, as part of EEIJMS, a subgroup of ten faculty and students updated the survey from our previous work and we have administered it to hundreds of first- and second-year undergraduates in mathematics courses as part of a new study of identity and belongingness in undergraduate mathematics education.

It is possible that our collaborative work will lead to concrete outcomes, such as peer-reviewed articles, presentations, and grant submissions. However, even without these, our collaboration has had many positive impacts. Through EEIJMS, we generate new ways of thinking about shared problems that we take back to our disciplinary work and into our classrooms. Pooja thinks differently now about the "math" part of math learning, based on a

richer understanding of mathematics as a discipline and practice, in turn influencing her other research collaborations within psychology. She has also been inspired to dramatically change her own teaching practice with respect to group work, based on conversation and experiences in the EEIJMS meetings. Ben interprets research papers in math education and psychology with a different perspective now that he's been through the data collection process and has learned more about study design. His perspective on social sciences research was particularly influenced after spending one session in an online discussion group with Pooja's research network, learning about the various factors (funding, disciplinary norms, disciplinary politics, etc.) that play a role in determining research directions in the social sciences. This changed how he thinks about the ways that social scientists develop their research programs. Also, in his own classes, Ben thinks about question design in new ways, taking into account what he has learned regarding the factors that impact how students answer questions. This has also influenced his approach to mentoring mathematics PhD students.

These are not outcomes that either of us would have predicted during our first conversation, and this is one of the wonderful qualities of collaboration, especially across disciplinary boundaries. While we can't predict what the next few years will bring, we know that our collaboration will continue to enrich our intellectual, professional, and personal lives.



Benjamin Braun



Pooja Sidney

Credits

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Photo of Pooja Sidney is courtesy of Pooja Sidney.

Building Community in the Classroom

Erica Winterer

At twenty-two years old, I started my teaching career in a New Orleans high school. My oldest student was twenty-one and on my fifth day, a sophomore named Malaysia asked me if I was trying to be Hilary Swank (referring to her *Freedom Writers* portrayal of Erin Gruwell, the American teacher known for her unique teaching method used to inspire at-risk youth to further their education). She wasn't wrong. Even though I knew next to nothing about my students' community, I thought I would make an excellent teacher because I understood the content. Misguided and over-confident, I muddled through my first two years of teaching. I wasn't the worst, but I definitely wasn't the best. My students undoubtedly deserved better.

After two years of teaching, I could finally manage the paperwork, mostly manage upwards of thirty teenagers, and keep the rats from eating the corners off the reward Starbursts; however, I was still blindly flailing through attempts to build "classroom culture." Always a pillar of professional development, but never clearly defined, classroom culture was a slippery, murky creature I would rather avoid than chase after. Every example offered to me seemed like some wizard teacher with a unicorn personality was able to effortlessly inspire groups of teenagers with their nebulous teacher moves. All the magic seemed to hinge on these teachers' personalities which were far removed from mine. I am not a particularly funny or gregarious person. I prefer small groups of people, have very few close friends, and avoid attention. The best choice I made was to stop imitating these examples.

Students valued my authenticity more than my ability to entertain them. We built community by building trust. I demonstrated care for students through high expectations, highly organized lesson plans, and praise for their individual progress. My investment in students' success and our shared responsibility for the course combined to foster and grow a community. I will never be Jaime Escalante (the Bolivian-American educator portrayed in the 1988 film *Stand and Deliver*) and that is fine. We can still build community without magic.

I had to repeat this mantra the first time I saw my graduate advisor, Uri Treisman, teach his freshman calculus class. He is one of those wizard instructors, seamlessly

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