"Specialization is the art of simplifying a problem until you solve it." If pressed I may add that you can vary polynomial systems by changing the coefficients of the defining polynomials. "The system might be easier to solve for some special coefficients—for example, if many of the terms of the polynomials are zero. I study how geometric properties of a complicated system can be deduced by studying simpler systems." I avoid any mention of flatness or schemes.

A simple example often conveys what we do more effectively than our latest technical progress. I once gave a one-minute presentation on my work at a Kavli Symposium of the National Academy of Sciences to a group of accomplished young scientists. I spoke about the problem of using specialization to find the number of lines intersecting four general lines in space. I asked the audience to visualize the problem and then I showed them a movie of the specialization. When two of four lines intersect, finding the two solutions is relatively easy and the audience was comfortable with it. By the time I said that I study higher dimensional analogues of this problem, my minute was up.

Pictures are potent communication devices. We can all be envious of colleagues who study complex dynamics and can show beautiful renditions of Mandelbrot or Julia sets, especially ones with names like Basilica, Rabbit, Airplane...

Catchy phrases can be effective in describing one's work. These evoke the main idea of the proof or the essence of an object at hand. "The dog on the leash theorem" or "train tracks" are good examples. Such slogans call to mind an idea, avoiding the accompanying long explanation.

Even if we find it hard to describe our most recent results, we can try alternatives that convey aspects of it. Applications, even if not implied directly by our own work, can be illustrative. We can explain a simple toy problem, even when this problem does not exhibit the main technical difficulties we face.

It can be fun to bring up certain problems, especially those you know may elicit strong reactions or whose solutions are counterintuitive. I have had spirited arguments over the Monty Hall problem. When people get upset, try not to lose your cool, acknowledge the solution may appear unreasonable at first glance, discuss more intuitive variants.

It is of course always important to be respectful of people. Most will have had a brief and often fraught exposure to mathematics. Nevertheless, they are often genuinely interested in hearing about the work that we do and will make a good faith effort to understand what we tell them.

Do not appear arrogant, condescending, or not willing to try. While sometimes we find ourselves at a party with a drunk jerk who isn't going to remember what we tell them anyway, most of the time there is an opportunity for honest communication. With some forethought, there is no need to switch to physics to do a reasonable job!

Izzet Coskun

Credit

Author photo is by Micah Block Weiss.

Communicating Mathematics Using Social Media

David Richeson

In the June/July 2019 Early Career column, Holly Krieger wrote about the importance of creating a high-quality online presence before entering the academic job market ([Kri19]). I agree wholeheartedly with her recommendations, but she focused mainly on what once was described as "Web 1.0." Approximately two decades ago, "Web 2.0," the participatory web, was born. In this article, I argue that mathematicians should take advantage of the interactive nature of the web and build an online network of colleagues, collaborators, mentors, and friends.

Social media sites are ubiquitous on the internet. We share photos of our kids on Facebook. Our pets and our food look great on Instagram. We argue about the day's political news on Twitter. We comment on how to fix a broken dishwasher on YouTube. But we can also use social media to communicate about mathematics and the profession.

Like many mathematicians, I find social media to be an essential part of my career. I have a blog, `divisbyzero.com`, and I am active on Twitter, where I am @divbyzero (see [Ric17]). I use social media for professional networking, for learning new mathematics, for improving my teaching, for learning about the pressing social issues in academia, and for having fun.

When I was asked to write this piece on communicating mathematics via social media, I knew exactly what I had to do: ask my Twitter followers what I should include in the article. Within moments, replies flooded in. What follows are my impressions of the benefits of having a professional

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social media presence informed by the comments of my followers.

Consuming and sharing mathematics. When I look at my Twitter feed, I see mathematical discussions, links to research articles, links to mathematics in the news, information about books on mathematics, problems and puzzles, photos of mathematical artwork, pedagogical conversations, career advice, conversations about equity in the profession, and real-time glimpses of conferences and workshops.

One can get a lot out of social media just by being a consumer of information—being a "lurker," as they say. But to get the most out of social media, it is important to engage in conversations. That is the "social" part of social media. So, make a Twitter account, start following people, and begin interacting. Post photos of found mathematics on Instagram. Make a video or podcast. Start asking and answering questions on one of the math-related Stack Exchange sites—MathOverflow, Mathematics, Mathematics Educators, and TeX.

For those who are so inclined, I strongly recommend starting a blog. My blog is available for anyone to read, but my main audience is myself. In the January 2019 Early Career column, Robert Lazarsfeld wrote about the benefit of keeping a mathematical journal ([Laz19]). That is great advice, and I treat my blog as a public journal. When I learn some new piece of mathematics or have a teaching experience that I think went particularly well, I write about it on my blog. Then the page is there for me the next time I need the information, and I get to share the idea with others. The commenters often provide ways to take my idea even further or point me toward resources I did not know about.

In his March 2019 Early Career column, Jordan Ellenberg encouraged mathematicians to write outward-facing mathematics ([Ell19]). Writing books, articles, and editorials for the general public is one way to do that. But social media is a much easier way to communicate mathematics to people who might not be mathematicians.

For years, the web was not conducive to presenting mathematics because LaTeX was unavailable. This is no longer a barrier. There are many ways to include beautiful-looking mathematics on the web. In fact, one of the great strengths of sharing mathematics online is that it opens up so many possibilities that are unavailable in print: videos, interactive graphing programs, animations, applets, downloadable files (such as 3D-printing files and data), and so on. Space is not nearly the issue online that it is in print. Plus, publication happens instantly.

Blatant self-promotion is awkward, but we would like people to read our articles and books. Social media provides a natural way of building a network of people who share your interests. They will follow along as you conduct your research, and when it is finished, they will be interested to hear about it. It happens organically. Also, social media provides an easy way to promote the work of your friends, colleagues, collaborators, and others.

One objection to blogging or tweeting about your scholarship is that someone might steal your work. Here, I suggest using common sense. Getting people excited about your work, getting feedback from other scholars, and finding potential collaborators are great benefits of writing about your work online. But it may not be wise to share work that is the key to a future publication.

Professional development. Like many mathematicians, I care deeply about teaching. I recognize that there are many ways to teach effectively, and there is always room for improvement. I follow people online who also care about and have thoughts about teaching. I have witnessed conversations about inquiry-based learning, standards-based grading, flipped classrooms, teaching using primary sources, and more. I have been prompted to rethink the way I teach certain material, and I have acquired new examples to use in my classes that either wow the students or target a known problem-point for new learners. I have been introduced to new technology that can be used to teach more effectively and efficiently. I have debated which textbooks to use (or not use) in a particular class. I have also been the recipient of the generous sharing of teaching materials.

There have been important conversations about diversity and equity in mathematics and in academia more generally that have gotten me to rethink how I interact with my colleagues and my students.

The best cocktail party. The internet is a place where we can rub shoulders with Fields medalists, best-selling authors, award-winning teachers, and experts in every area of mathematics. It is exciting to eavesdrop on their conversations and to correspond with them directly. But there are many other interesting mathematicians online: professors at research universities, teaching institutions, liberal arts colleges, and community colleges; high school and middle school teachers; students at all levels; mathematical artists; applied mathematicians; pure mathematicians; statisticians; data scientists; mathematics enthusiasts; historians of mathematics; textbook authors; popular book authors; puzzle makers; journalists; people from every corner of the world; engineers; physicists; computer scientists; and people in the business world. There are women, men, people of color, members of the LGBTQ community, introverts, and extroverts.

Find your community, whether it is people in your research area, women in mathematics, people who enjoy discussing pedagogy, members of the LGBTQ community, or mathematicians with your religious or political views. Or better yet, build a diverse community so you can hear all of these voices. Social media allows us to interact with people at various stages in their careers, in different geographic locations, with different backgrounds. For instance, even though I teach at the college level, I find it very interesting and inspiring to follow high school mathematics teachers.

One criticism of the modern web is that it creates silos—filter bubbles that prevent people from seeing outside their own worldview. I'm sure that is true in some cases. But in the mathematics community, I see the opposite. It is easy to see why a graduate student might think that mathematics happens only at R1 research universities and that anyone who does not end up at such an institution is not a mathematician. But through social media we see the true diversity of mathematics and of mathematicians. We can be successful in many more ways than by solving a famous open problem or by producing PhD students. I have been inspired by and have learned from middle school teachers, parents who run math circles, mathematical artists, and other people not considered to be "mathematicians." The sense of community is real and powerful. In fact, these social media platforms humanize the superstars. We see that they live ordinary lives, they make mistakes, they have gaps in their knowledge, and they care about students, the profession, and the world.

Social media is a great resource for isolated academics—mathematicians who do not have access to a local research community. Many research collaborations emerge out of social media connections. Social media duplicates some of the benefits of attending conferences, which are becoming increasingly more difficult for many academics to attend, whether it is for financial, personal, or geographical reasons.

Words of warning. The online world can be toxic, and we make ourselves vulnerable by putting ourselves out there. It can be especially bad for women, people of color, members of the LGBTQ community, and individuals in other underrepresented groups. Before writing this article, I reached out to friends who are members of these groups. They reported many more positive experiences in mathematical social media than negative ones. The one exception was MathOverflow, in which the ability to downvote questions and answers, to close conversations, and to comment on responses make it an unwelcome place for some of them.

My personal golden rule for social media is that it should not be a new source of stress. If a Twitter user tries to start an argument, I don't reply or I block the user. There's a familiar internet warning: "Don't read the comments." I would not offer that advice in mathematical social media; some of the best ideas come out of online conversations. However, comments can be hurtful, especially when a blog post goes viral and trolls come out of the woodwork. In such cases, ignore the comments, delete them, block the commenters, or turn off the commenting function for the page altogether.

There is also the possibility that a social media user could damage his or her personal or professional life by posting an inappropriate joke, photo, or comment. We warn our children to be careful about what they post online, but it is important for us to remember this as well. Do not post something on social media—regardless of what you think your privacy settings are—that you would not want to be in the *New York Times*, in the newsfeed of all of your students, or in the hands of your provost.

Who to follow. I have avoided recommending specific blogs to read, people to follow on Twitter, or YouTube channels to watch. There are many good options, and each person should build his or her own circles. But as a start, one might visit `truesciphi.org`, which has lists of mathematicians on Twitter and mathematicians' favorite Twitter feeds. Also, mathematicians may enjoy the Twitter hashtags #mathchat and #mtbos ("math Twitter blogosphere"). For blogs, one might peruse the AMS's "Blog on Mathematical Blogs" (`blogs.ams.org/blogonmathblogs`), which is updated regularly. Or, for a one-stop-shop, the MathFeed app.

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David Richeson

Credits

Author photo is by Mark Richeson.

Using the arXiv

Greg Kuperberg

Although these days virtually everyone in the mathematics profession knows something about the arXiv, a small introduction may still make sense before turning to advice about using it. (First of all, it is officially just "arXiv," but many people like to say "the arXiv." I am in the latter camp

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