

Instead of using both a capital and lowercase version of a letter, such as  $\phi$  and  $\Phi$ , use different letters unless they are very closely linked. Otherwise, it is too hard to distinguish the two while talking, leading to awkward statements like “little  $\phi$ ” and “capital  $\Phi$ .”

- Do not introduce new definitions or a new topic in the last five minutes (the exception being a short talk). Instead, use this time to sum up main points, describe future directions, or address the experts.
- Do not reveal your own insecurities with comments such as “my result is trivial” or “I would extend the result to case X, but I don’t understand X” or “I am sure everyone in the audience knows more about this.” Never belittle your own work, as there are many other people who would be happy to do this for you.

### Finishing Up

Do not rush the talk, but do not go over. It is better to finish with a minute or two left rather than keep impatient people in their seats for extra time. Be prepared for questions at the end and leave time for the audience to ask them.

Keep in mind that you, the speaker, know more about your work than the audience does. So relax, good luck, and enjoy yourself.

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## Meta-Morphism: From Graduate Student to Networked Mathematician

*Andrew Schultz*

While the stereotypical mathematician is a hermit locked alone in their office, the typical mathematician is far from a solitary explorer. A great amount of the mathematics produced today is created collaboratively, spurred into existence during those quintessentially mathematical social interactions: on chalkboards following a seminar talk, on napkins during a coffee break at a conference, on the back of a coaster at a pub. Though it often isn’t clear to those wading through graduate programs, one of the key meta-mathematical skills one should develop while working on a master’s or PhD is the ability to participate in this social

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network. What follows is a rough guide to how you can use graduate school to build the professional relationships that will shape your career.

### The Hungry Caterpillar

Stepping into the mathematical social network begins by getting to know your graduate student cohort. It’s likely that some of the friendships you form during graduate school will be among the closest in your life, and even those fellow students who aren’t your best friends are likely to be professional colleagues long after you’ve received your degree. It’s worth the investment of time and energy to foster these relationships as your first semester begins.

When arriving on campus to start your graduate career, you’ll likely convene with the new graduate students in your department and a handful of the faculty for a kind of informal orientation. PhD programs often draw students from a wide variety of backgrounds, so don’t be surprised to find people whose professional experience, familial status, or country of origin doesn’t match your own. Despite any differences you might notice at first, this group has a common bond with you that you’ve probably never experienced: shared professional passion and the dedication to pursue an advanced degree over the course of several years. Use this commonality to bridge social or cultural gaps that your classmates might settle into upon arrival. Fortunately your busy class schedule will leave you with plenty of excuses for convening *en masse*: to tackle lengthy homework assignments, to review topics covered in class, to prepare for qualifying exams. As you work toward your degree, you will rely on the various skills and perspectives that your fellow classmates can offer, so it is in your best interest to meet and spend some time with as many in your incoming class as possible. As you progress through the program, you might be surprised to find your ideal study partner, your favorite office mates, and your mathematical siblings aren’t the people you might have guessed when you first arrived.

Although mathematics and the novelty of graduate school are convenient starting points for meeting other incoming graduate students, don’t rely on math to be the only tie that binds you: meet people for pizza at the end of a long week; organize a hike at a local nature preserve; or set up an informal, weekly grad student happy hour. Chances are good that graduate students who are further along in the program will be organizing various social events to which you’ll be invited, and these will provide you with a good opportunity for meeting people whose experience can be of great benefit to you, both within the program and in your extra-mathematical life. Again, it is to your benefit to meet as many of the graduate students in your department as possible, so band together with a few first-year students and jump into this wider social pool. This larger community will also give you a chance to find people whose nonacademic interests match your own, and your department’s graduate student email list

can be a boon for collecting people together to join in your favorite sport, play your favorite game, or take in a local theatrical performance. You can also consider broadening your social circle outside the math department by looking for university-wide student groups organized around your particular interests; being a mathematician certainly doesn't oblige you to spend time only with other mathematicians, and the break from an otherwise mathematically centered life could be a welcome respite.

Once you've established yourself among the graduate students, you'll next want to get to know your local faculty. Departments typically have a number of social activities planned through the course of the year, from annual get-togethers like a fall barbecue to weekly afternoon tea breaks. These give you a good opportunity for interacting with faculty members outside of the classroom, and you should take advantage of this opportunity. Chat with your algebra professor about where the course is going, talk to your analysis professor about the REU project you worked on, or try to find some nonmathematical interests you share with other faculty. These conversations will give you an indication of which professors you most easily relate to, and this is an important factor to keep in consideration when choosing your thesis adviser. If you don't give yourself the chance to interact with a faculty member who is a candidate for becoming your PhD supervisor, you might find yourself spending an hour each week with someone you can't talk to. Also, when considering a candidate for your supervisor, you will want to take advantage of the connections you've made with older graduate students by asking them about experiences they may have had in working with this person; for obvious reasons, it is particularly helpful if you can get an honest assessment from a current advisee.

### Pupal Growth

Once you've gotten through your first year of graduate school, you are likely to have gravitated toward one research group or another within your department, and it's important that you become an active part of this community. Some of this will happen in the traditional classroom, where you already know the rules of engagement, though seminars will play an increasingly important role as you develop as a mathematician. Generally speaking, a seminar talk is a fifty-minute presentation to mathematicians in a specific discipline about recent developments in their field; often, but not always, the speaker at a seminar will be visiting from another mathematics department.

Once you've decided on your dissertation topic, you should start attending local seminars in your research area. Before attending, though, you'll need to adjust your expectations from those you have of a typical class. Seminar speakers have a limited time in which to introduce their topics, discuss connections to larger problems in the area, and then present specific results. Since the target audience is almost always specialists in the field, speakers often don't

spend time bringing nonspecialists up to speed. As a graduate student who might have limited background in the discipline, you could very well find that many (if not all) of the seminars you attend are mostly incomprehensible to you. Not only is this okay, but it's the experience of nearly every graduate student who attends a seminar; it's hard to drink from a fire hose. Don't let this discourage you from attending future seminars, and don't turn the seminar into your personal fifty-minute nap session.

Your job when attending seminars is to focus on understanding as much of the talk as you can. Bring along a notepad and write down any questions you think of. Don't expect that your questions will sound as fancy as those being asked by the senior faculty member you're sitting next to; you're just starting in the area, and you're not expected to be making esoteric connections. Instead, bullet point the big ideas of the talk: what were the basic objects under investigation? What qualitative information did the stated theorems give about these objects? How do the stated theorems depend on or diverge from each other? When the talk is over, you should feel free to participate in the question-and-answer session even if your questions don't sound as sophisticated as others. Afterward you should certainly speak with an experienced faculty member—if at all possible, the seminar speaker—about some of the questions you had. This adds an additional ten minutes to your seminar experience but can put the fifty minutes you've already invested into perspective. What's more, by attending seminars you'll be training yourself to learn mathematics in an important way: contrary to the foundation-building, semester-long methodology used in teaching known mathematics, this result focused, hour-long seminar approach is how you're most likely to hear about (and personally disseminate) new developments in your area for the rest of your career. For this reason, it's important to keep attending seminars even if you feel as though you're not understanding all of the talks. Each additional seminar will fill out your understanding of the discipline as a whole, and soon you'll find that a talk you've just attended reminds you of another talk you heard two months before; you'll be weaving your own mathematical tapestry.

The other benefit of attending seminars is that they are occasionally preceded by a seminar lunch or followed by a seminar dinner. Graduate students are always encouraged to attend these informal gatherings, and oftentimes their meals are subsidized. What graduate student doesn't like a cheap meal? These get-togethers are a golden opportunity to interact with faculty members outside of your department (think "future postdoc mentors," "future coauthors," etc.), so you should make a regular habit of attending. Striking up conversations in these settings is usually very easy. Questions like "Where did you attend graduate school?" and "What made you start researching...?" seem obvious, but they are great places to begin. As always, don't feel obliged to stay within the bounds of mathematics when

making conversation; after a long day of focusing on work, a nonmathematical topic of conversation could be a welcome change. Without prying or excluding others from the conversation, explore connections that you might have: perhaps the speaker hails from somewhere you've been meaning to visit, or one of your undergraduate professors went to the speaker's graduate school. Remember that these meals are meant to be fun; relax, be yourself, and make a good-faith effort at participating in the conversation.

### The Emerging Butterfly

As you progress in your graduate career, you'll likely have the opportunity to speak about mathematics to an audience of mathematicians, either on your own work or on some theory you've been studying for your dissertation. If you are offered such an opportunity, take advantage of it. One doesn't develop the ability to give an interesting mathematics talk without experience, and you'll want to give yourself as many opportunities as possible to hone this critically important craft.

There are a number of excellent guides for how you can give a good mathematics talk (flip a few pages back to read the preceding article, or see [BS99, Hal74b, McC99, Swa09], or talk to someone whose presentation style you admire), but don't forget the interpersonal component of talking to an audience. Do the basics well: make eye contact regularly, gauge the audience's understanding and make necessary adjustments. The audience will sense and respond to your attitude, so you can help encourage an enthusiastic response by projecting your own interest when describing your results. Along these same lines, avoid self-deprecating humor and resist the urge to downplay the importance of your results because they don't seem as profound as topics you might have heard while attending past seminars. The increased accessibility you detect in your talk comes from the fact that you have spent a lot of time developing the mathematics which bolsters it, and most of your audience won't have the benefit of this prolonged exposure to your topic. In other words: what seems obvious to you is often not immediately obvious to those in attendance. Help the audience follow your talk by providing them with interpretations of the results you present, such as how a certain lemma will be used in developing a later theory, or why a particular result is connected to previous work in the area.

Don't feel that you need to give your first talk in a research seminar filled with faculty. Instead, see if the graduate students in your department have a student-run, general-interest seminar that you can speak in. If no such seminar exists, take the lead and start one. Graduate-student colloquia can be a tremendous opportunity for you and your cohort to sharpen a critical professional skill in a low-stakes, friendly environment, and your department will be stronger for the introduction of such a seminar. Approach your department chair or the director of your graduate program and see if you can get some nominal funding to

support the seminar, and use the money to entice student attendance with that siren song of graduate life: free food. Presenting in such a seminar will force you to boil your technical results down into an understandable form, and you'll reap the benefits of seeing how your classmates perform this same reduction. As you go on to present in seminars with faculty attendees or with a more specialized focus, you'll rely on this same skill (though you'll need to adjust the parameters of "understandable" depending on your target audience). Even if you don't plan to keep research as an active part of your professional life after you finish graduate school, this skill remains applicable for the many times you have to talk about mathematics to non-mathematicians: when explaining the importance of a subject to a class of undergraduates, or when justifying some mathematical program to administrators at your college.

After you've had a chance to present work locally, you'll want to take advantage of any opportunities which arise for presenting talks at nearby meetings or at far-flung conferences. There is often support for graduate student travel, either from your department or the conference's organizing body, so don't assume that an empty bank account will prevent you from participating. Occasionally you can also receive support even when you aren't presenting at a given conference, or you might have the opportunity to attend a conference which won't require outside support (if it's at a local university, say). If you are given financial backing, or if the out-of-pocket expenses are manageable, it's always a good idea to attend conferences which cover mathematics of interest to you when you have the opportunity. Don't feel obliged to limit your participation to conferences organized around your specific research area; your mathematical interests are likely varied, and your professional life will be richer by fostering this breadth.

Once you've arrived at a conference, don't forget that there's more to do than simply attend talks (or deliver your own). Conferences represent an opportunity to further your social sphere and make contacts with some of the movers and shakers in your field, or at least a handful of mathematicians who are a bit further along in their mathematical careers than you. This will likely be the first time in a while that you've felt like you truly know no one around, but don't let that be an excuse for making a quick retreat to your room at the end of each talk. Don't be shy about introducing yourself to people during coffee breaks or in the ten-minute pauses between talks or presentations. Again, basic introductions can take you very far, so feel free to start with your name and institution and see where things go. At the beginning of a conference, you can always ask if the person will be presenting later in the week; if you've already seen their talk, you can ask them something you didn't get a chance to ask during the question-and-answer period (you're still writing questions down during talks, right?). Take advantage of this opportunity to establish

yourself as an inquisitive, approachable person to a large group of people outside your home institution.

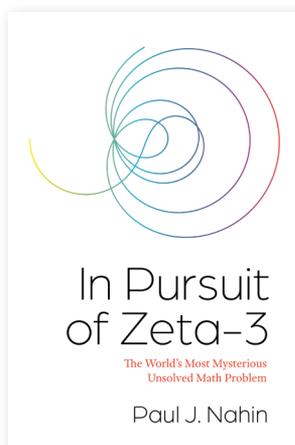
### Life as a Pollinator

Life as a professional mathematician requires participation in a social network, and graduate school represents an ideal setting for you to gradually develop the skills and connections which will help you thrive in this web: first with your classmates, then local faculty, and later with the wide mathematical world. Regardless of where you end up after graduate school, continue to take advantage of the opportunities you have to further your own connections, and do your part to help budding mathematicians at your institution join this network: foster their interest in exploring and presenting their own mathematical questions, encourage their attendance in colloquia or seminars (or help organize a student-targeted colloquium), and convince your department to set aside funds so they can attend conferences to meet other mathematicians. By placing value on the interpersonal aspects of practicing math, we ultimately increase the quality of mathematical content and discourse for those we seek to serve: our institutions, our students, our colleagues, and ourselves.

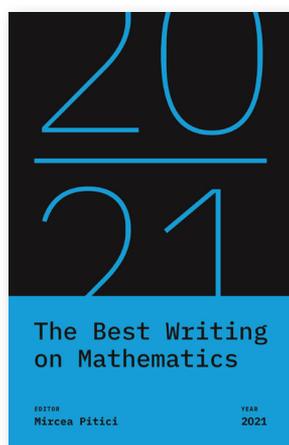
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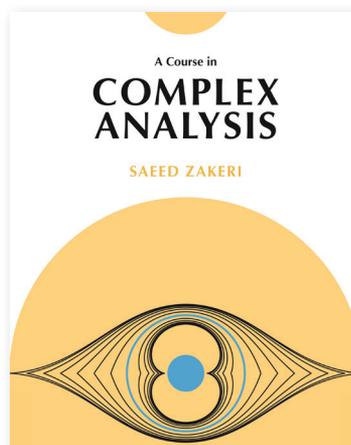
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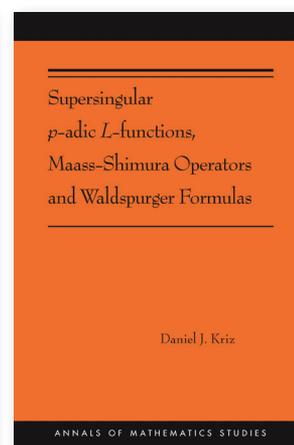
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