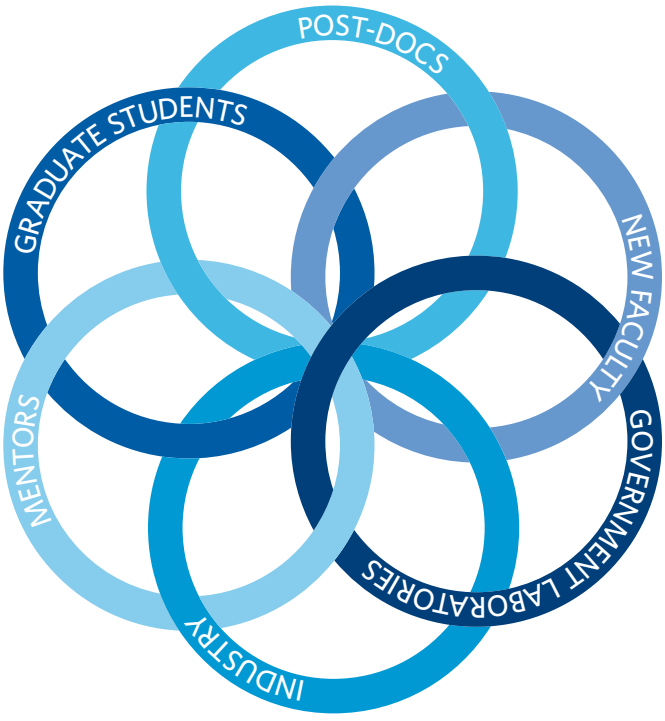
The Early Career Section offers information and suggestions for graduate students, job seekers, early career academics of all types, and those who mentor them. Angela Gibney serves as the editor of this section. Next month's theme will be writing.



Research

How to Proceed in Mathematics

Skip Garibaldi and Daniel M. Gordon

We'd like to share with you the following piece of advice:

How to proceed in mathematics

1. *Work on hard problems.*
2. *Do some whimsical math.*
3. *Share your ideas.*
4. *Understand your colleagues' strengths.*
5. *Try to find someone who knows something that you don't know who is willing to work with you on your problem.*

This is remarkable advice, so let's remark on it. (We'll tell you about where it came from later.)

The first two items talk about how to pick problems to work on. The recommendation to work on hard problems should feel familiar. It's what the famous people in the history books did. If you are paid to do math research, then working on hard problems is what you are expected to do. If you do math research for personal growth, then challenging yourself is a key part of achieving that growth.

The second item, to work on whimsical math, is less standard. You may know that Richard Feynman broke out of a prolonged lull in his research by thinking about a whimsical problem concerning how a thrown plate wobbles. The exhortation here is more general. It says to do some whimsical math as a matter of course, as part of your regular practice, not just to get out of a long-term rut.

The rest of the items are about the human interaction side of doing research. Contrast their message against the stereotypical story of a lone genius who does solo battle against the hard problems and brings back understanding (for all) and glory (for themself). These items are focused less on individual glory and more on having fun and enjoying being part of a mathematical community.

We find this advice inspiring because it advocates for a way to be a mathematician that we find personally fulfilling. We love the social aspect of doing research with others. We love learning from other people, proving theorems with them, and ultimately writing papers with them that are more fun to read and include stronger theorems than anything we could have written on our own. These are the personal rewards from following this advice.

We also find this advice inspiring from a different perspective, when we think about what it would mean if everyone took it. From that perspective, the guidance from musty histories seems designed to produce a culture that maximizes the glory received by a few individuals. Contrast this with the advice here, where the last two items seem aimed at improving a culture's ability to actually solve the hard, important open problems. Sharing your ideas also helps to solve hard problems faster, and it de-emphasizes individual credit. In summary, in comparison with the solitary struggles of the lone mathematician, this advice

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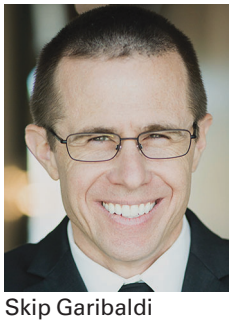
suggests a path that is more pleasant for the individuals involved and leads to an overall culture that will actually solve more hard problems. What's not to like?

Where This Advice Came From

This advice was part of the last public mathematics talk given by Warwick de Launey before succumbing to cancer at the young age of 52. Warwick spent most of his career working on classified mathematics, first in Australia and later in the United States, mostly at the IDA Center for Communications Research in La Jolla. He was named a Distinguished Member of the Crypto-Mathematics Institute for his contributions. He was active in traditional academic mathematics, too, especially combinatorics and design theory, as you can see in his book [1] or the special issue of *Cryptography and Communications* [2] in his honor. His long list of publications and many collaborators attest to him having lived his professional life following this advice.

References

[1] W. de Launey and D. L. Flannery, *Algebraic design theory*, Mathematical Surveys and Monographs, vol. 175, American Mathematical Society, Providence, RI, 2011.
[2] D. L. Flannery and K. J. Horadam, *Guest editorial for the special issue on design theory*, Cryptogr. Commun. **2** (2010), 127–128, DOI 10.1007/s12095-010-0035-x.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Credits

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Keeping a Problem List

Alexander Perry

One of the hardest parts of mathematical research is finding good problems, where "good" means some combination of interesting and doable. For this reason, I think it's important to document our ideas for good problems as they occur to us—especially when we don't have time to investigate them at the moment—before they get lost in the commotion of life. This was my original motivation for starting my own problem list, which I've since come to appreciate for its other benefits as well.

First, how do you keep a problem list? The simple answer is to record any potential research idea that comes to you, but I've found the following habits helpful:

1. Follow the arXiv listings in your subject. When a paper appears that interests you, skim through it to get a general sense of what is proved. Try to think of questions that the paper leaves open, or which could be accessible using its methods, and record them in your list. (You don't need to understand all the details of the paper at this point—that comes later, if you decide to work on the problem.)
2. Attend seminar talks regularly. Again, keep an eye out for open questions, or potential new applications. Discussing with the speaker is a great way to gauge whether you've come up with a good problem.
3. Actively talk about math with others, whether in classes, seminars, conferences, the common room, or online. Record interesting problems that arise, as well as with whom you discussed them, in case you want to resume the conversation later.
4. Every once in a while, do maintenance on your list. This includes organizing the list (e.g., by subject or priority), following up on recent activity and background, and reformulating problems or making them more precise. Sometimes, this process will help inspire new ideas too.

Once you have a problem list, what are its uses? There are a variety of them, beyond the obvious one of being a source of fresh research directions:

1. A problem list's existence can be psychologically useful even if you aren't ready to start a new project. It's reassuring to have a supply of problems waiting, especially in those times when you find yourself stuck on your current research. I've also learned that simply the act of writing down a problem can start ideas percolating—by the time you "officially" begin work on the problem, you may have already subconsciously developed an approach to it!
2. A problem list makes grant writing much easier, and perhaps even fun. Indeed, you can treat grant writing as an opportunity to flesh out approaches to some of your favorite problems on the list.
3. A problem list can be a tool for productive math conversations. When you attend a conference or visit a department, ask experts about aspects of your problems. Sometimes this will help you refine your questions, or even start a collaboration.
4. One day, your problem list will probably contain many more problems than you could ever hope to investigate. Don't worry, there is still a great use for those problems: they can serve as starting points for your students' research.

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