Becoming a Researcher: A Reflection

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PROLOGUE

Viewed one way, Alan Schoenfeld's main lines of research and Katie Lewis's dissertation have almost nothing in common. Alan's work has focused on understanding mathematical thinking and teaching, while Katie's work has focused on mathematical learning disabilities. Viewed another way, there are strong overlaps and strong parallels. In what follows we explore the similarities, characterizing how each of us developed a sense of self as a researcher. Along the way we describe the somewhat meandering path each of us took to get to our current areas of scholarship, reflect upon how our 'outsider' status afforded us a novel perspective on the questions we care deeply about, and discuss the affordances of the apprenticeship model for our own teaching and learning.

Alan

I was blessed with a thesis advisor and a postdoctoral mentor who, whether by intention or accident, wound up being exactly right for someone with my personality. If you tell me what to work on and what rules to follow I'm likely to get bored and resist, but if you give me rope I'll happily tie myself in knots and maybe hang myself too –part of the pleasure and risk of being 'out there.' Following my intellectual passions is what drives me to do my best.

In the late 60s and early 70s, graduate students in mathematics at Stanford were allowed to create their own courses and to teach them for credit, as long as the courses didn't overlap substantially with the standard offerings. I loved teaching, so the course policy offered some neat opportunities. I'd been intrigued by some mathematical objects with rather strange properties. For example, there are the "same" number of points in the line segment between 0 and 1 as there are in a square that's 1 unit on a side. That's weird—something that has no area has as many points as something that has an area of 1. In fact, you can build a function that maps the unit interval onto the unit square, using something called the "Cantor set." I decided to teach a course on such objects.

Amazingly, some students enrolled. I dreamed up some problems for us to work on, and as we came to understand the objects better, I dreamed up some more problems. It was fun. When the semester was over I was left with some problems I hadn't solved, so I kept working on them. (Part of who I am is that I need to understand how things work. So if there's a problem that I think is interesting and haven't solved, I keep working at it.) My advisor, Karel deLeeuw, said he thought the problems I was working on were interesting, so I kept at it. I checked in with him every few weeks, showing him what I'd figured out.

Some time later Karel said, "You have more than enough for a dissertation. Clean up what you have and write it up." At that point I had to do my homework and read the literature. I discovered that along the way to proving my main result I'd spent 4 months (distilled down to 30 pages of manuscript) proving a named theorem. Oh, well. If I'd been a better scholar I would have saved a few months. Or maybe not, because it's one thing to read the work someone else has done and quite another to figure it out for yourself. My intensive explorations helped me to really understand the mathematical objects I was working with; moreover, they reinforced my pleasure in digging deeply into what I wanted to understand. I absolutely loved that kind of work.

While I was working on my dissertation, the job market was collapsing around me. It was hard to find a job when I finished, and when I got my first position as a faculty member I warned prospective doctoral students that there might not be jobs available when they finished. I said then, and I still believe that you should only go to graduate school if you are willing to invest a number of years writing a dissertation and then, if faced with unemployment, be able to say "That was so much fun that it was worth it."

In that first position as a lecturer in mathematics, I was disturbed by the value system of the institution. Some of my senior colleagues told me I was spending far too much time with students, and that I should shut my office door and prove theorems. I complained about this to a friend who worked in education. She said I should talk to Fred Reif at Berkeley, who headed an interdisciplinary group in what we now call cognitive science and education. By that time I had read Pólya's work on problem solving, and I was genuinely intrigued—the strategies Pólya talked about resonated, but the literature showed that students didn't learn them. What if we could make sense of them? That could make a *big* difference. Fred and I talked, and he offered me a postdoc during which I could learn to do educational research. Then he told me that if he were in my shoes, he wouldn't take his offer; at the end of a 3-year postdoc I would no longer be a mathematician, and I wouldn't have any real credentials as an education faculty member, so I'd be unemployable.

I happily ignored his advice and took the postdoc. The idea of pursuing problem solving was genuinely intriguing. I'd need to dig deep (which I loved), but if I succeeded the work might have real impact. Fred's instructions were simple: I should read until I felt I was literate and then get to work. Well, I read fast and get bored easily, so within my first year I started on some empirical work related to problem solving—and I've never looked back. I should note that Fred was a horribly good critic: he taught me that I had to be as rigorous in my educational work as I had been in mathematics. The freedom I was granted to pursue issues I really cared about, along with the rigorous training to do things right, were the essentials in getting me started. Being grounded in mathematics, but not being limited by the current paradigms and perspectives in educational research also turned out to be to my advantage. For better or worse, I could look at issues of thinking and learning without being hampered by current research methods. I looked at what I thought was important, inventing methods as I went along.

And now the golden rule kicks in. I just can't force other people to do things I wouldn't want to do myself. As an advisor, I've always done what I can to provide my students with the kinds of opportunities I had as a beginning scholar. My advice has always been simple:

> Find something you care passionately about and want to understand more deeply. Ground yourself in empirical phenomena because theory only makes sense if it's built and refined through dialectic with empirical reality. Start asking questions. They're likely to be too big to explore, but don't worry. I'll help you carve them down to manageable size.
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> If you're working at the edge of what we know, the odds are that the field doesn't have methods to answer those questions. That's not a problem—it's an opportunity! The career skill a scholar needs to remain at the cutting edge is to figure out how to make progress when there aren't known methods. If you can do that in your dissertation you'll be on your way. I'll be a resource and a sounding board, but you'll be doing the heavy lifting. In doing so you'll be building the skills that will serve you over the course of your career.

Over the years I've built structures that support my students in this kind of work. The "functions group" at Berkeley is a home for research in mathematics education, where its members (master's and doctoral students, postdocs, visiting scholars, and anyone else who's willing to pitch in) help each other explore issues at the edge of their understandings. It's a safe place, where you can bring half-baked ideas and have them refined. And it's a microcosm of our "apprenticeship" program where one learns by doing (and reflecting).

The group grew and evolved from my earliest days at Berkeley. When there were only a few of us (me, my then-postdoc and friend, Abraham Arcavi, and a small number of graduate students), we simply worked together. Then, as the program got larger and more students joined us, I realized that working as part of a functioning team was a far more powerful way of learning to do research than reading about it and having private consultations with an advisor. Finally, as we grew larger, functions morphed into two separate but overlapping groups to accommodate the research and apprenticeship aspects of our work. One group focused on the projects for which I was responsible. Some people were interested in those projects, and they typically were members of both groups. But, as I've mentioned, my job is to support all my students in following their passions—some of which don't fall under the umbrella of my current work. So, the second group was defined as a place where my advisees, and anyone else, could bring their issues for discussion. The only condition for membership: you have to take everyone's work seriously and contribute to the discussions of their work because when it's your turn, you want people to do the same for you. For a look at the current functions group, see <http://functions.berkeley.edu/>. For a more extended discussion of how we work, see Schoenfeld (1999).

Fast forward to 2004, when I was the principal investigator of the Diversity in Mathematics Education (DiME) program at Berkeley, and we were recruiting students. Katie Lewis contacted me and told me that she was really interested in doing research on students with mathematical learning disabilities. Does that count as diversity? I said, "Yes," and Katie joined us. She'll take the narrative from there.

Katie

Although my official training as an educational researcher began in 2004, my journey toward researching mathematical learning disabilities began much earlier. When I was eight years old I was diagnosed with dyslexia. This diagnosis was, in some ways, a huge relief. I had been struggling to learn to read. The diagnosis meant that my brain worked differently than other kids' brains. I realized that I would have to work much harder to learn how to do things my peers learned easily. This personal experience with my own learning disability has fundamentally shaped how I approach my research. Although disabilities are often talked about in terms of deficits (e.g., Katie has a deficit in phonological awareness.), I find that it is more productive to talk about them in terms of differences. I think these differences matter. Although I have figured out ways of compensating over the years, I can still 'feel' the differences in how my brain works. To this day I still can't sound out words that I've never heard spoken aloud, and I have difficulty reading aloud fluently. My early experiences and challenges learning to read were the genesis of my interest in disability.

My interest in mathematical learning disabilities, specifically, emerged many years later when I started tutoring students in algebra. I noticed that some students had significant and surprising difficulties working with representations of quantities. These difficulties were reminiscent of my experience learning to read. In an educational psychology class in college, I first read about mathematical learning disabilities. I was hooked. To learn more I wrote a thesis reviewing the research on mathematical learning disabilities, but I was disappointed in what I found. At the time very few studies focused on mathematical learning disabilities, and those studies focused exclusively on documenting the students' deficits. Statistical analyses of errors on various performance measures did not speak to the complex and perplexing experience of working with someone with a mathematical learning disability. Suspecting that there was a better way to meaningfully connect this research to learning, I decided to apply for a Ph.D. in education.

I was incredibly fortunate to make my way to Berkeley as Alan's advisee. Alan gave me—and his other doc students—the freedom and responsibility to develop and pursue our own research interests. Unlike many advisors, Alan did not expect us to carve out a small slice of his research for our dissertation. There was no well-conceptualized pre-existing project in which we were supposed to find our dissertation. He pushed us to develop our own independent line of scholarship. During my time at Berkeley Alan's students explored a huge range of topics. At the core of each was something that the student felt a sense of passion for, wonder about, or drive to learn. Alan encouraged his students to find something that was innately interesting and follow that line of inquiry.

One way in which Alan supported his students to develop their own identity as a researcher was by encouraging us to "fail early, fail often." He cited this mantra in my first semester when I sheepishly explained that I was uncomfortable videotaping myself interviewing a student. For a new graduate student embarking upon my very first attempt at research, the "fail early, fail often" mantra was comforting. It gave me permission to make mistakes—I didn't have to be perfect. From this initial 'failure' I was able to understand the analytic power of video to capture the nuances of a student's response, and I was able to reflect upon my interview technique and become a better listener, a better interviewer, and a better researcher. "Fail early, fail often" helped me take the first steps into empirical work, but the idea behind the mantra is larger than that. From my first semester at Berkeley, I was designing and conducting research, trying to figure out how students understood mathematics. Alan's perspective, reflected in the "apprenticeship" nature of my Ph.D. program, is that it is important to get out and start doing research early so that you begin to understand the complete enterprise in which you are engaged.

Just like Alan's experience in his postdoc position, there came a point where I needed to deeply immerse myself in the literature in my field. Although I had extensive coursework in theories of learning, methods, and mathematics education, I needed to become more fully versed in mathematical learning disabilities research, specifically. One of the program requirements at Berkeley is to complete three qualifying papers (called "position papers") before the oral exam. The first two are traditionally empirical, and the last is often a literature review. As I prepared to write my second position paper, I realized that I needed a broad view of research on mathematical learning disabilities. Because of Alan's willingness to give his students some "rope," it was relatively easy to convince him to go along with this somewhat atypical ordering of papers. I spent many months immersing myself in the literature, which drew from the fields of education, psychology, and neurology. My literature review helped me understand the field and how to position my own work in relation to it. The understanding of the field along with grounding in the empirical phenomenon enabled me to develop a theoretical perspective that was distinct from the traditional deficit-model paradigm.

My dissertation explored how two college students with mathematical learning disabilities understood fractions. This work may seem disconnected from Alan's work on understanding teaching and learning of mathematics—but throughout, I can see clear evidence of his influence. I learned to appreciate the power of understanding learning through microgenetic analysis—examining small changes over time. I learned the necessity of "mucking around in the data" (as Alan would say) as a methodological step toward making sense of them. In rereading Alan's chapter and my article, reprinted in this issue, I am struck by the similarity of our data representations. My representation of the learning of two students over time mirrors Alan's representation of the problem-solving process. Alan instilled in me the importance of capturing how the learning and doing of mathematics unfolds over time. Because of this, I realize that I have Alan to thank for my somewhat compulsive need to attempt to portray the whole of the data I've collected. Although this increases the rigor and scope of analysis, it also makes squeezing analyses within journal word counts challenging.

In rereading Alan's chapter I noticed that, in many ways, the research process mirrors the problem-solving process described by Pólya (1954). "Mathematics may appear sometimes as a guessing game; you have to guess a mathematical theorem before you can prove it, you have to guess the idea of the proof before you carry through all the details" (p. 158). Particularly for under-researched and under-theorized fields, you have to make a guess and see it through until the end—even though it may be impossible to know where that end will be when you begin pursuing it. I 'guessed' that there was something to be revealed in understanding the difficulties that emerged as a student with a mathematical learning disability attempted to learn. I followed that hunch down the analytic path it led me. Guessing, however, can only get you so far. "The devil is in the details." (another of Alan's mantras)—and so it was. Although mucking around in the data is a necessary first step to get a sense of the story they are telling you, you can't stop there. Once you have convinced yourself, you try your best to convince yourself of the opposite. Ensuring that you have the 'right' story involves testing out all the other possible interpretations of the data—and then running your arguments by a collection of critical friends, who do you the favor of subjecting your arguments to refinement by fire. This practice calls to mind Mason, Burton, and Stacey's (2010) discussion of mathematical proving, in which they recommended a three-stage process: "convince yourself; convince a friend; convince a skeptic" (p. 87), a very useful sequence for making arguments in educational research as well.

Although both Alan and I have emphasized the importance of developing an independent researcher identity, the process of developing that identity is not solitary. Throughout my time at Berkeley the functions group provided the backbone of my graduate experience. There were several critical components of functions that meaningfully shaped my development as a researcher. First, I had the opportunity to be apprenticed into the work of graduate school. I watched more advanced students navigate the Ph.D. milestones as I read qualifying papers, watched oral exam practices, and read dissertation proposals and chapters. Being in functions concretized the process of progressing through graduate school and provided models for success. Second, functions demystified the research process. As other students and Alan shared works-in-progress it was possible to witness some of the messiness involved in the research process. This provided a vantage point on the research enterprise that is not often evident in the polish of published research. Third, functions provided a space to share my own work. It was an incredible experience to have the other 10 to 20 people in the room engaged deeply with my research. I made more progress each time I presented than I could have made in weeks of solitary work, causing me to believe deeply in the power of collaboration in the research endeavor. Fourth, and perhaps most meaningful to my teaching, is that functions taught me how to *give* feedback. Alan and more senior students modeled giving constructive feedback. As I started giving others feedback I realized that I was also getting feedback on my feedback. Sometimes others would agree with a suggestion or a comment, and sometimes they would disagree. Over my years in functions I learned how to engage deeply with my peers' work and provide meaningful and helpful feedback. When I began my tenure-track position I was prepared to teach doctoral seminars and advise Ph.D. students, largely because I had been apprenticed into the practice of giving productive feedback. I'm not only the researcher I am today because of functions, but I am also the advisor and teacher I am today because of functions.

Katie and Alan

There are several themes common to our stories of becoming researchers. We both entered our fields as outsiders. We both were fortunate to have advisors who gave us the trust and freedom to follow interests and instincts, while teaching us to be rigorous in our pursuit of ideas. And, we both believe deeply in the power of the apprenticeship model and the social nature of the research enterprise.

As outsiders, we weren't limited by the structures that constrained the field. Structures are great because they enable us to build upon a base, but they can also constrain the ways in which we allow ourselves to approach a problem. We both had lived experiences with the phenomena that we were interested in studying. These experiences grounded us. Alan wasn't constrained by previous thoughts about problem- solving; Katie wasn't constrained by the deficit models typically used to study mathematical learning disabilities. Ultimately, we became hybrids—building on our intuitions *and* learning the tools of the trade. We believe this balance is essential, even for people entering a well-established research enterprise. Living at the cutting edge requires constant invention, so one must know the tools at one's disposal and then go on to refine and expand them.

We also want to emphasize the fundamentally social nature of learning, and the need to build powerful learning communities. Katie noted that becoming a scholar involved much more than learning to write papers, and that support for her professional growth came from a community, not just an advisor. Functions group provided a safe environment where people could venture ideas and have them vetted. There's an interesting process of legitimate peripheral participation. "Newbies" often start by listening and then venture a comment in reaction to something they hear. Often, because they're not caught up in the research culture, the freshness of their ideas adds to the conversation. As they get braver, they also get more central, and they're participating in conversations as increasingly knowledgeable insiders. When a student presents, those who are more junior see the kinds of issues they'll be facing and learn how they're dealt with; those who are more advanced share their knowledge and develop their mentoring skills.

As noted earlier, the functions group started on the Berkeley campus—but the idea of functions extends far beyond Berkeley's borders. Katie is one of many alumni who carried the idea with her. As Katie started her faculty position at the University of Washington she tried to figure out how to set up similar structures for junior faculty and graduate students. She organized a writing group, open to all junior faculty, that meets weekly to share and get feedback on writing—for example Katie shared an early version of this commentary article. She also negotiated with the Dean to create her own functions group for graduate students interested in qualitative research. She had seen the power of this kind of institutionalized group for moving students' research forward and did not want to embark upon supporting master's and doctoral students without building this kind of community. Katie's research group shares many of the same features as functions. It is a safe space for graduate students to bring their ongoing work to share during one of the two presentation slots each week. But, unlike Alan's group, which has a history and more senior members to apprentice junior members, Katie needed to build from the ground up. She told her first cohort stories about the Berkeley functions group, how it had operated, and why it had been so meaningful for her development as a researcher. She spent time deliberately and jointly constructing the norms by which the group would operate. With just a few structures and scaffolds in place, the group began operating just like the Berkeley functions. From the first quarter her research group appealed to graduate students who were eager to have additional support beyond the qualitative methods course offerings. Now, after three years, much like the Berkeley functions, it has developed a shared history and culture of apprenticeship within itself.

It's long been an adage that "Once a member of functions, always a member of functions." Graduates are always welcomed back, whether for a quick visit (sometimes including a presentation and feedback) or for a sabbatical leave. The extended functions family (currently 85 members) remains connected through email: if you have a question, there is an international community of scholars ready to lend a hand. As members of the functions group the two of us are much more than advisee and advisor, and we share much more than a history of time together. We're two members of a vibrant intellectual community that is a great source of personal and intellectual gratification. The functions family continues to grow and is continually enriched by new family members.

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